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NDUSTRY AND
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After the flood—Restoring equipment to service after inundation is discussed briefly by Samuel R. Lewis on page 196

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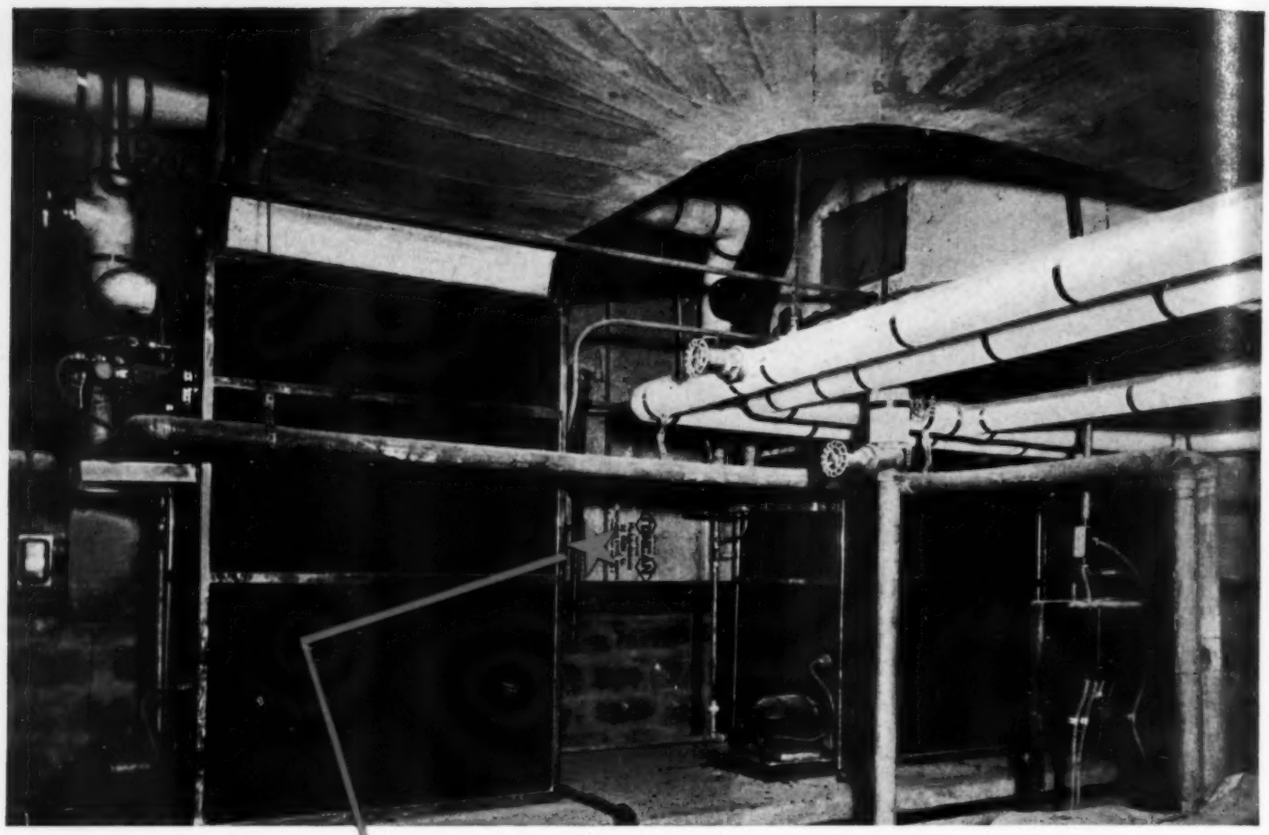
Ventilating Engineers



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THE EDITOR'S PAGE

April, 1936

A NEW name appears as a member of H. P. & A. C.'s Board of Consulting and Contributing Editors this month, listed on the second page following—that of R. D. Touton. Mr. Touton is Technical Director of Bayuk Cigars, Inc., makers of Bayuk "Phillies" and other well-known brands and has had a wide experience with industrial process air conditioning. . . . Most recent of the several articles he has written for H. P. & A. C. was published in January, summarized the result of ten years' experience in operating process and comfort air conditioning systems. . . . Data on the business advantages of air conditioning are always of interest and are useful to the consulting engineer, the plant or building engineer or management, and to others, in evaluating a proposed investment in an air conditioning system. . . . A number of articles presenting information along these lines have appeared in past issues under the general heading "What Air Conditioning Did for My Business"; this month, A. J. Rummel describes an office air conditioning job which it is estimated paid its operating cost through reduction of lost time because of sickness of employees. . . . It is suggested that readers keep a file of articles of this kind—more of which will appear in coming issues—for ready reference.

It's getting to be a habit—activity in air conditioning exceeding each year that for the preceding year. In St. Louis, air conditioning activity is 100 per cent over the same period in 1935, according to a reliable estimate. . . . Installations during February, 1936, in Chicago were 72 per cent over February, 1935, totalling 1,472 tons as compared to 851 tons, according to the Commonwealth Edison Co.'s figures. . . . Carrier Engrg. Corp. has consolidated at its home office at Newark, N. J., personnel responsible for engineering, installation and service on contract air conditioning work for the eastern territory; the move was made necessary by the continued growth of the larger type of installations which are done directly by Carrier's own construction department, according to L. R. Boulware, general manager. . . . Carrier recently received a $170,000 contract for completely air conditioning the Younker Brothers department store, Des Moines, Iowa; the job comprises seven floors and basement with a total of 233,000 sq ft. Cold water taken from two deep wells will be supplemented by 650 tons of centrifugal refrigeration. Charles S. Leopold is the consulting engineer. . . . "Air conditioning offers a market possibility of at least 200 per cent more business than was done last year," according to J. A. Harlan of Kelvinator Corp. "Most of this will be commercial installations for restaurants, hotels, theaters, stores, beauty parlors, funeral homes, dance halls, auditoriums, etc." Kelvinator is conducting the fourth and final of the series of its schools April 6-17 at its factory to provide air conditioning engineering training for engineers of several new distributors.

Walter L. Fleisher is to speak on air conditioning from a promotional angle at the 47th annual convention of the Heating, Piping and Air Conditioning Contractors National Association at Philadelphia, May 25-27, according to the preliminary program just released. . . . Other subjects to be discussed, in addition to numerous committee reports, include voluntary codes, housing, unemployment insurance, standardization, and certification. . . . Attacking recent proposals to sidetrack formation of a federal public housing agency, *Public Housing Progress* for March states that both the abandonment of PWA's condemnation suit before the Supreme Court and the recognition by the President of the need for subsidies to construct low rent housing constitute twin victories for public housing advocates. . . . A public housing tour of Europe is to be conducted by Helen Alfred, secretary of the National Public Housing Conference, this summer; the group is to sail July 8 on the *Queen Mary*.

. . . Working models and operating displays will be emphasized at the Wisconsin air conditioning exposition scheduled to be held May 12-16 at the Milwaukee Auditorium. . . . As the result of a large number of meetings of American Society for Testing Materials standing committees, held in Pittsburgh during "committee week" early last month, many new standard specifications and methods of test are to be recommended to the Society. In all there were about 100 meetings, including main standing committees, their sections and subcommittees. The total registered attendance for the group meetings was about 625, exceeding that of any previous year. . . . Recent publication of the third annual report of the Engineers' Council for Professional Development, 29 W. 39th St., New York, N. Y., makes available to engineers and educators a record of the activities of this body, providing information on the organization, purposes, policies, personnel of the council and the work of its four major committees on student selection and guidance, engineering schools, professional training, and professional recognition. . . . The 36 page report contains a list of the participating bodies and their representatives for 1935-1936, the report of C. F. Hirshfeld, chairman of E. C. P. D. for 1935, committee reports, the charter and rules of procedure, policies adopted since its formation, a brief report on finances, and the committee personnel for 1935-1936.

The Minneapolis heating code, recently published in the form of a 72 page booklet, is divided into 17 parts covering general provisions, estimating heat required for warming a building, determining amount of radiation, indirect heating surface, capacity and installation of boilers, chimney flue area, pipe sizes and piping connections, gravity and mechanical warm air heating, ventilation and air conditioning, oil burner, gas burner and stoker installations, and validity, violations, penal and effective clauses. . . . Louis Clousing is inspector of buildings.

Which article in this month's H. P. & A. C. most interests you? On what subject would you like to see more articles? The Editors would like to know, as it will be helpful in developing material for future publication, will aid them in editing H. P. & A. C. to meet your every-day needs and interests; your cooperation in filling in and returning the coupon on this page will be appreciated.

The Editor,
HEATING, PIPING AND AIR CONDITIONING,
Six North Michigan Avenue,
Chicago, Illinois

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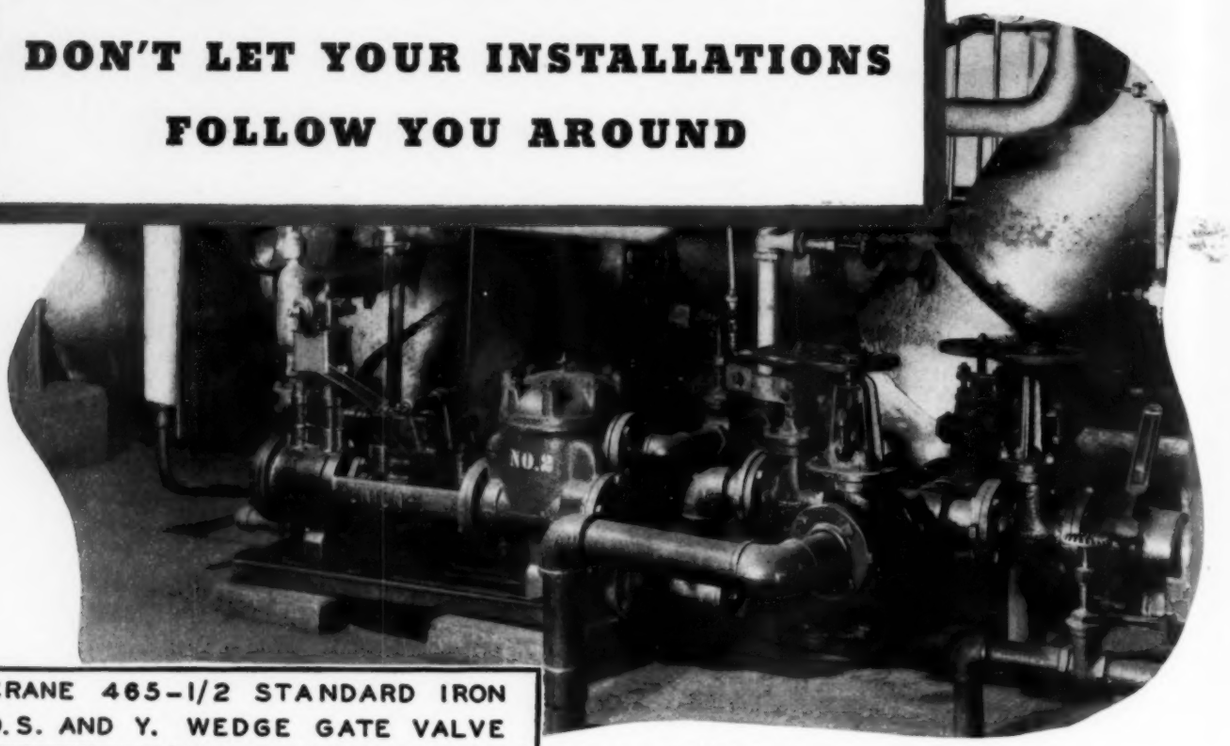

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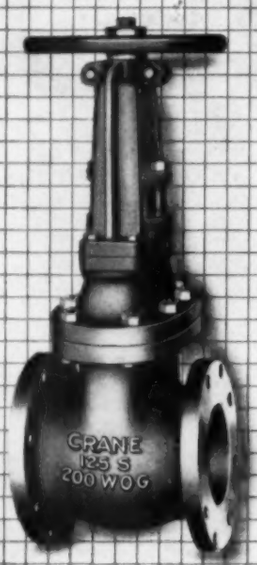

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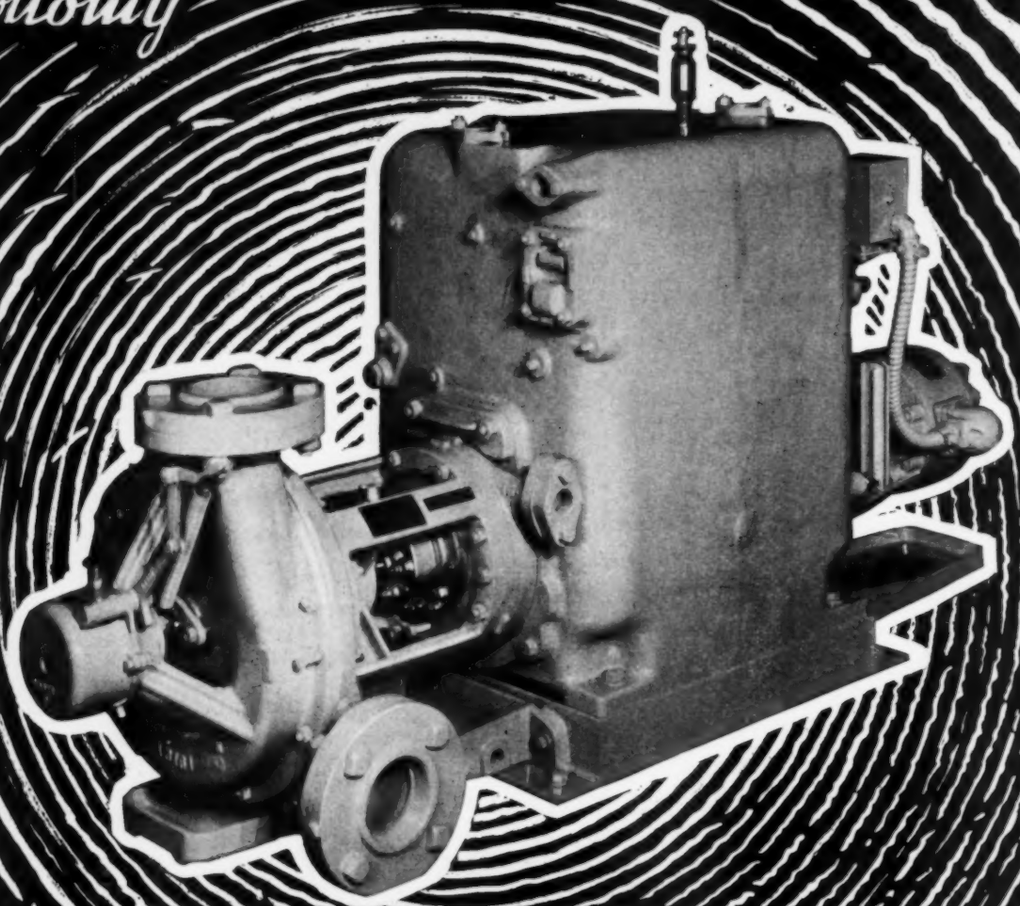

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Heating · Piping and Air Conditioning

Vol. 8, No. 4 • *April, 1936*

DESIGN OF MODERN INDUSTRIAL PIPING SYSTEMS

SUPPORT OF PIPE LINES

By **F. L. Snyder*** ***and*** **T. E. Bridge†**

Supplementing previous data on spring hangers for piping and determination of the distance between supports, which attracted wide and favorable attention, the authors present this month a method and the necessary charts for determining the proper size of supporting columns and foundations for piping.....Several examples clarify the use of the data given

A PREVIOUS article[1] of the same title presented data on the design of spring hangers for the support of piping systems, and for the determination of the distance between pipe supports. The present article, which supplements it, is a description of a simple and safe method for determining the size of the supporting columns for pipe lines. The discussion is based on columns of circular section, which are preferred for many reasons, among which are economy in the initial installation, and in the maintenance of the system. Other factors favoring the circular section are:

1—Uniform strength in all directions about its neutral axis.

2—The cost of fabricating pipe supports from circular section is no greater than that of the structural section.

3—A quantity price advantage may be enjoyed when purchasing the pipe if the quantity includes the supports.

4—The surface area of the circular section varies from 20 to 50 per cent less than that of a structural section having the same strength. This reduces the cost of painting, both material and labor, in the same proportion.

5—The circular section pipe support lends itself more readily to additions than does the structural section, in that it is a simple problem for maintenance field crews to make additions either with welding or screw or flanged fittings.

The only disadvantage of the circular section that has come to the attention of the authors is corrosion at the base of the column where it enters the concrete foundation. It may be overcome by pitching the top surface of the foundation toward the outer edges as shown in Figs. 1 and 2, and by giving the pipe a coat of pitch at this point before finishing the top of the foundation.

The advantages of this type of supporting structure are so apparent that this discussion is confined to this

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†Engineering Department, E. I. duPont de Nemours & Co., Inc., Wilmington, Del.

[1]HEATING, PIPING AND AIR CONDITIONING, February, 1936, pp. 93-99.

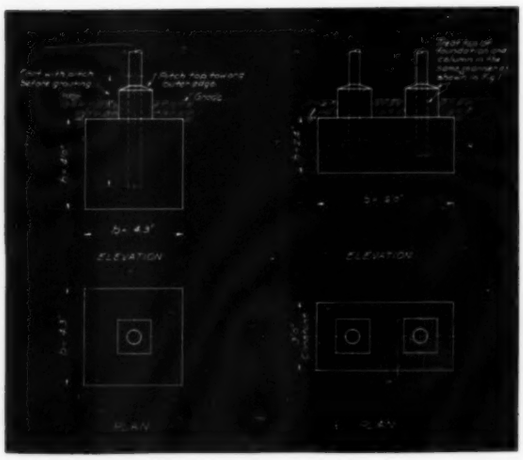


Fig. 1 (*left*)—Foundation for single column pipe support
Fig. 2 (*right*)—Foundation for double column pipe support

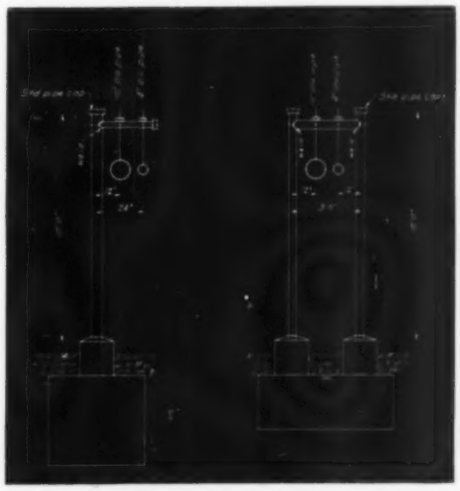


Fig. 3 (*left*)—Single column pipe support
Fig. 4 (*right*)—Double column pipe support

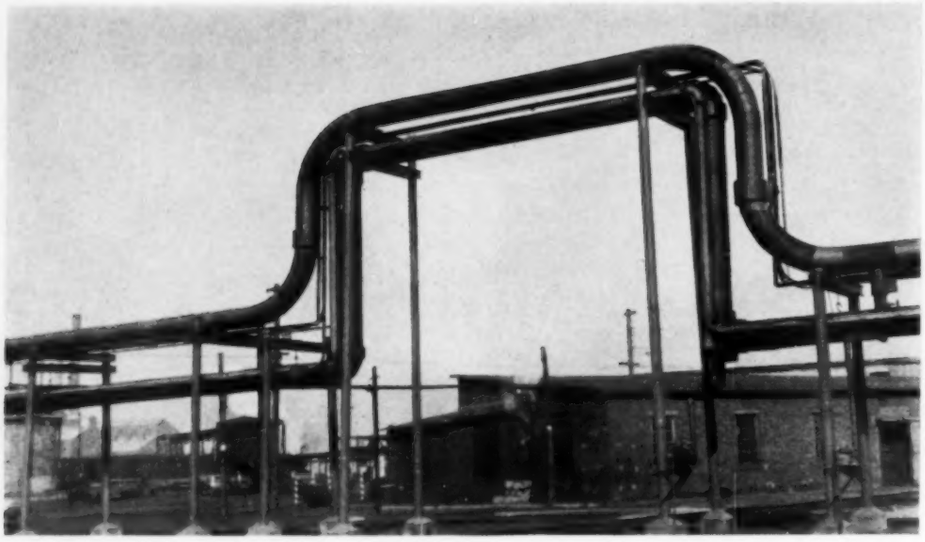


Fig. 5 — Double pipe supports having structural cross members

type. Of course, it is realized that in complex supporting structures the use of the circular section would not be logical, but this condition is beyond the scope of this article. The methods described here are for use when designing a simple pipe supporting system, such as is encountered by the designer in every day practice. This applies also to the method of designing simple concrete foundations described. It will be noted that in the case of foundations, dead load is not considered, since usually the overturning moment is so much greater than the dead load that the latter becomes a negligible factor.

Preference is given to hanging the pipes from the supporting structure, rather than supporting them directly on it. Therefore, in the following, the design of the supporting structure is based on columns having overhanging arms from which the pipe is supported. Fig. 3 shows a single column support with an overhanging arm, which is designed to take the dead and wind load of the piping system. Fig. 4 shows a double column support, the cross member of which is designed not only to take the dead load, but also for strength to stiffen the supporting structure to resist overturning moment set up in the structure by wind load. The size of this member is determined arbitrarily and is assumed to be the same as the column section. The economic advantage gained by designing it for a definite overturning and dead load is negligible.

Advantages of Circular Section Supports

A detailed study of the strength of various commercial sections, including structural shapes, has shown that the circular section is more suitable for pipe supports; this is particularly true in the case of the single column support of Fig. 3. For instance, assume a column 10 ft high designed to withstand an overturning moment of 80,000 lb. Allowance is to be made for the variation of the strength of the column with the slenderness ratio L/R. It is found that a 6 in. full weight steel pipe section weighing 19 lb per ft is required, while if an I beam section were used the size would be 8 in. and weight 18.4 lb per ft. If an H section were used the size required would be 5 in. and the weight 18.9 lb per ft. It will be noted that the weight varies but little. The surface exposed to weather requires periodical painting for protection against corrosion, and in the case of the pipe section is much less than with the structural sections.

So far as strength is concerned, the pipe section has the advantage through a definite size range, as it has stiffness in all directions from its neutral axis, while the strength of the structural section varies as the direction of load. A carefully designed pipe supporting system also considers the load due to thermal expansion of the pipe line; these forces are considerable if the temperature difference is high and if the pipe is supported directly on the structure. Attention is called to several cases of this nature wherein the supports have failed in the direction parallel to the pipe line. The consideration of this condition is less complicated when a circular section is used, because the pipe section has equal resistance to bending in all directions. Therefore, if the column is designed for extreme conditions, other load factors entering design are negligible.

A comparison of the strength and material cost of different sections of relative weight is given in the following table. The cost of the pipe section is based on the base rate of $0.03 per lb while that of the structural section is from the base rate of $0.0325 per lb; the effective height is taken as 10 ft.

Column Section	Max. Overturning Moment, In.-Lb	Total Weight of Column, Lb	Surface Exposed, Sq Ft	Cost of Column
6" F. W. Pipe	105,000	190	17.35	$5.70
8" I Beam	82,000	184	26.60	5.98
5" H Beam	82,000	189	25.00	6.14

Design of the Supports

When designing supports for a piping system, it is necessary to consider:

1—Dead Load. (Weight of the pipe to be supported, including insulation, weatherproof covering, and ice if any).

2—The eccentricity of the dead load. (Distance from the center of the column to the center of the load, measured along the overhanging arm).

3—The overturning moment created by wind load.

4—The slenderness ratio of the column, L/R. (which is the length divided by the radius of gyration).

5—The strength of the material in the column.

The fundamental formula most commonly used for steel columns, which takes into account all of the above factors, is:

$$S = 16000 - 70\,L/R = W/A + M/Z$$

where:

S = Allowable compressive stress for steel in lb per sq in.

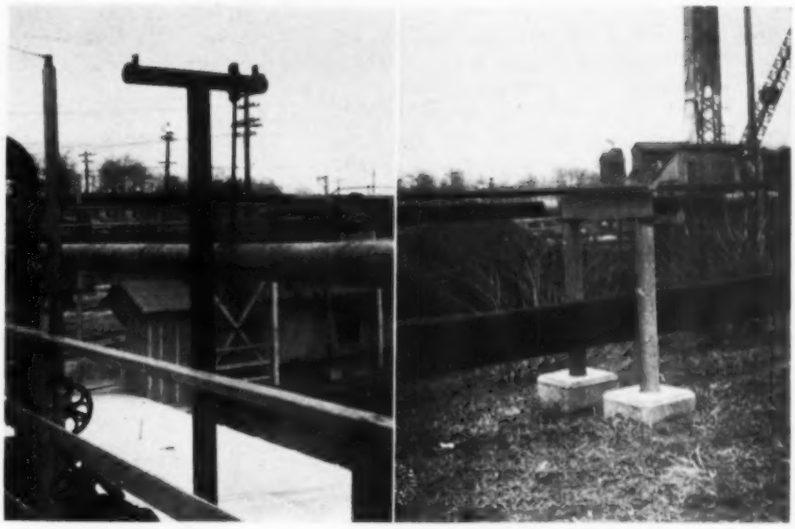


Fig. 7 (*left*)—Single pipe support entirely welded. Fig. 8 (*right*)—Low double pipe support with structural member welded to top of columns

L = Height of column, in.
R = Radius of gyration† of column section, in.
W = Total dead load to be supported from the column, lb.
A = Metal area† of the column section, sq in.
M = Overturning moment due to wind and eccentricity of dead load, expressed in lb-in.
Z = Section modulus†, in.^{3} (moment of inertia divided by distance of farthest fiber from neutral axis).

Fig. 9 has been prepared to simplify the use of this formula. The term "W/A" was neglected, as in practically all cases the wind and eccentric loading are so great in comparison with this term that it can be omitted without introducing any appreciable error. It has been found that for any eccentricity of loading which is greater than the diameter of the column, or when the distance from the center line of the column to center of load is greater than column diameter, the error introduced by the omission of the term W/A is not noticeable.

†See Table 2, p. 96, February, 1936, Heating, Piping and Air Conditioning.

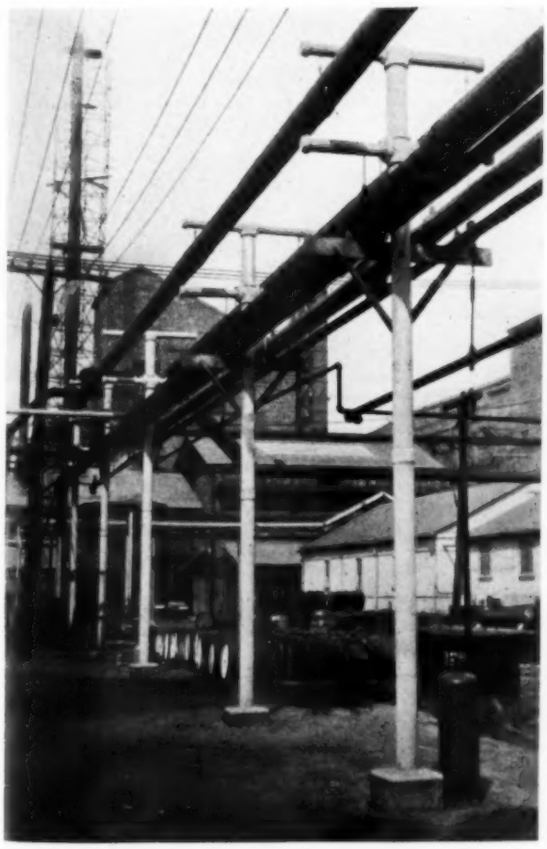


Fig. 6—Single pipe supports fabricated with standard screw type fittings

An explanation of the use of the curves shown in Fig. 9 is given by the following example:

Assume two pipe lines to be supported from a single column support, the height of which is 10 ft above the foundation. One pipe is 10 in. full weight steel, having a total weight of 1000 lb. It is to be supported from the overhanging arm a distance of 12 in. out from the center of the column. The other pipe is 4 in. full weight steel, having a total weight of 200 lb, and is supported from the overhanging arm 24 in. out from the center of the column. The distance between supports is 20 ft. The wind pressure on the projected pipe surface is 25 lb per sq ft. The projected surface of the pipe exposed to wind pressure is assumed to be the outside diameter (including insulation) multiplied by its length

First, calculate the force created by wind. (Diameter of pipe in feet, multiplied by the distance between supports in feet, multiplied by the wind pressure in lb per sq ft) or

For the 10 in. pipe

$f = 0.8958 \times 20 \times 25 = 448$ lb

For the 4 in. pipe

$f_1 = 0.375 \times 20 \times 25 = 188$ lb

Second, calculate the overturning moment due to wind. (Total length of the column in inches, multiplied by the wind pressure in lb) or

For the 10 in. pipe

$F = f \times 120 = 448 \times 120 = 53760$ in.-lb

For the 4 in. pipe

$F_1 = f_1 \times 120 = 188 \times 120 = 22560$ in.-lb

Third, calculate the overturning moment due to eccentricity of loading. (Total dead load of the pipe line, multiplied by the distance from the center of the column to the center of the load, measured along the overhanging arm) or

For the 10 in. pipe

$E = 1000 \times 12 = 12000$ in.-lb

For the 4 in. pipe

$E_1 = 200 \times 24 = 4800$ in.-lb

Then the total overturning moment due to wind pressure and dead load is the arithmetic sum of the moments calculated or

$M = F + F_1 + E + E_1$ *or*

$53{,}760 + 22{,}560 + 12{,}000 + 4800 = 93{,}120$ in.-lb

To determine the size of the column which will safely resist this overturning moment, see Fig. 9. Referring to the 93,120 = Max. Moment line on the chart, and following this line straight

across to the right, at the point of intersection of the vertical line 10 = Height of Column, it is found that a 6 in. F. W. steel pipe column is necessary, since the located point on the chart occurs between the 5 and 6 in. size columns.

The function of the overhanging arm is to support the dead load of the pipe only, and is treated in the case of the single column support as a cantilever beam. Therefore, it is considered to be equal to a column of zero height. In this example the overhanging arm is designed to support the dead loads E and E_1, or 12,000 + 4800 = 16,800 in.-lb. To determine the size of the overhanging arm, see Fig. 9. Referring to the 16,800 = Max. Moment line on the chart at the point of intersection of the vertical line 0 = Height of Column, it is found that a 2½ in. F. W. steel pipe is necessary.

Where the load makes it necessary to use double column supports, as shown in Fig. 4, the curves of Fig. 10 are used in the same manner as are the curves in Fig. 9.

For example, assume the same values of loading as described in the above case for single column supports, and that the columns for the double column support are 3 ft apart. Calculate the overturning moment due to wind in the same manner as described above. In this case the eccentricity of the dead load is determined by the distance of the load from the nearest column. Now calculate the moment due to dead load:

For the 10 in. pipe

$$E = 1000 \times 12 = 12000 \text{ in.-lb}$$

For the 4 in pipe

$$E_1 = 200 \times 12 = 2400 \text{ in.-lb}$$

Then, the total overturning moment due to wind pressure and dead load is the arithmetic sum of the moments calculated or

$$M = F_1 + F + E + E_1 \text{ or}$$

$$53{,}760 + 22{,}560 + 12{,}000 + 2400 = 90{,}720 \text{ in.-lb}$$

To determine the size columns which will safely resist this moment refer to Fig. 10 and proceed in the same manner as described in the case of the single column support. In this case the columns necessary will be 4 in. F. W. steel pipe.

As stated above the size of the cross arm is arbitrarily determined to be the same as that of the columns in order to stiffen the structure to resist overturning moment.

Design of Foundations

The foundations of a pipe supporting structure are equally as important as is the structure itself. In many cases conditions that enter foundation design are not pertinent to the supporting structure, and therefore an investigation of local conditions is necessary before design is completed; among these conditions are soil pressure, nature of the soil, if fill, or solid ground, space available, etc. With this thought in mind the following discussion is confined to simple concrete foundations that can be used under average conditions.

When designing foundations for pipe structures, it is always found that the overturning moment is the greatest factor. If the foundation is designed properly to resist this moment, the dead load of the structure will be amply provided for. To resist the overturning moment, weight, spread, and depth of the concrete are the necessary components in the design. The definition of these conditions may be expressed as:

$$W = hb^2 \times 150 = Pb^2/2$$

and equating the moments:

$$M = 12Wb/6 = 300hb^3$$

where:

W = Total weight of the foundation, lb
h = Height of the foundation, ft
b = Length of one side of the square, ft. (Assuming the foundation to be square at the base)
M = Overturning moment, in.-lb
P = Minimum allowable soil pressure, lb per sq ft
150 = Weight of gravel concrete, lb per cu ft

Fig. 11 was constructed to simplify the use of this

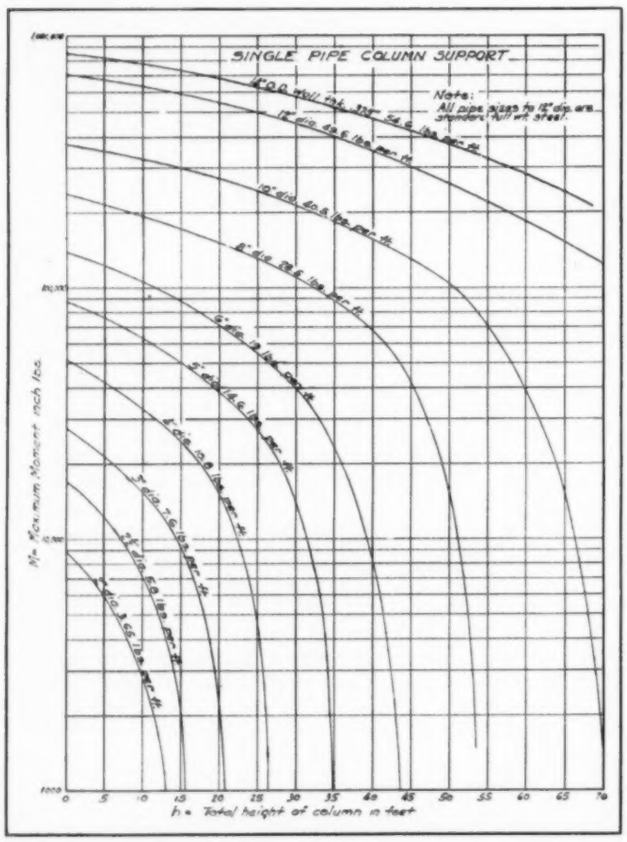

SINGLE PIPE COLUMN SUPPORT
Note:
All pipe sizes to 12" dia. are standard full weight steel.
Max. Moment inch lbs.
h = Total height of column in feet

Fig. 9—Single pipe column support

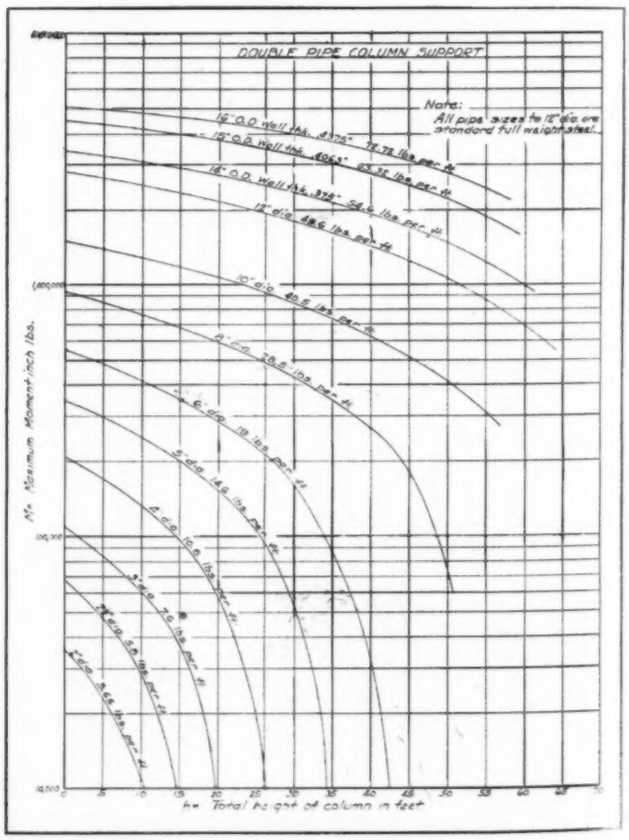
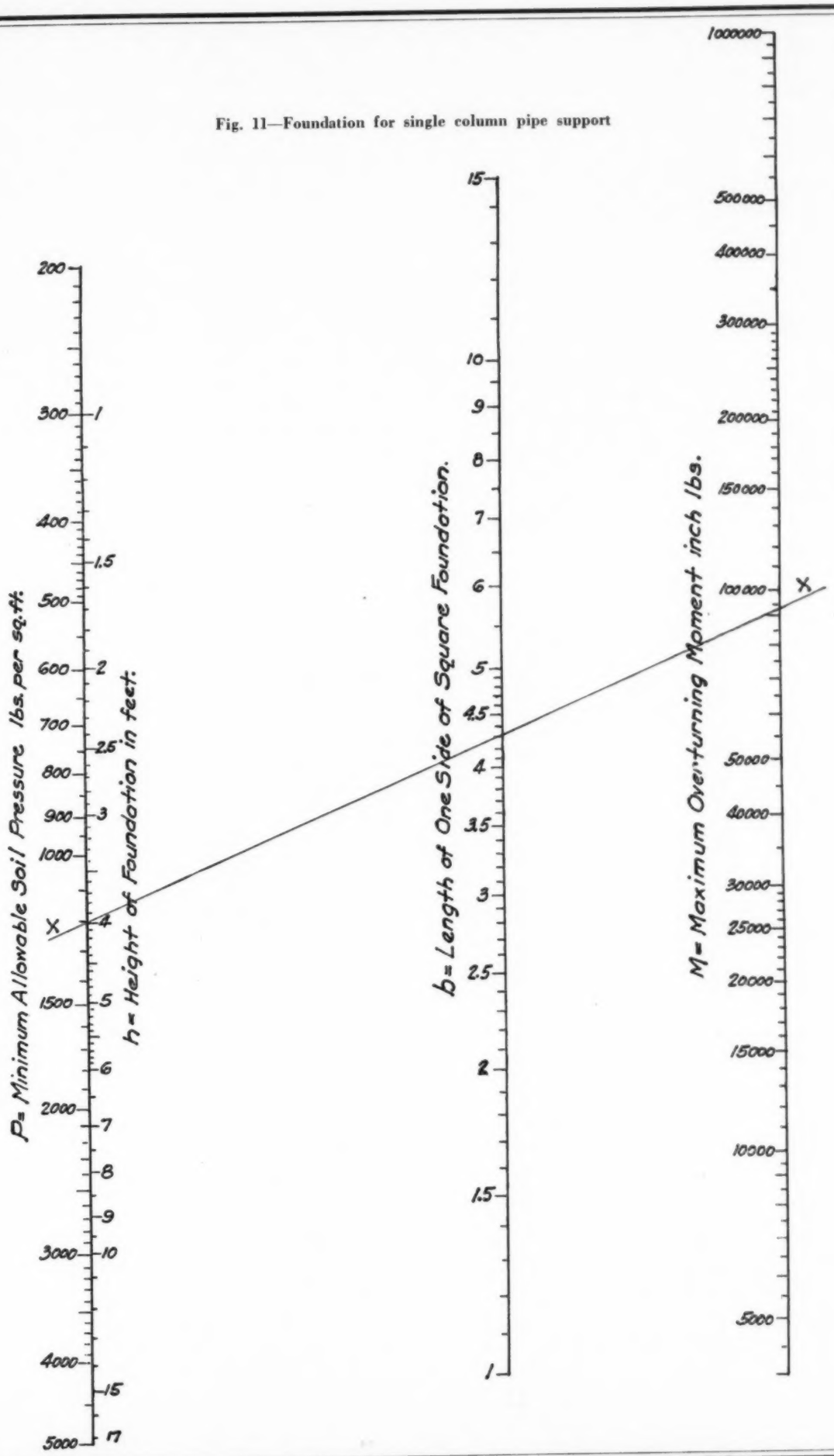

DOUBLE PIPE COLUMN SUPPORT
Note:
All pipe sizes to 12" dia. are standard full weight steel.
Max. Moment inch lbs.
h = Total height of column in feet

Fig. 10—Double pipe column support

Fig. 11—Foundation for single column pipe support



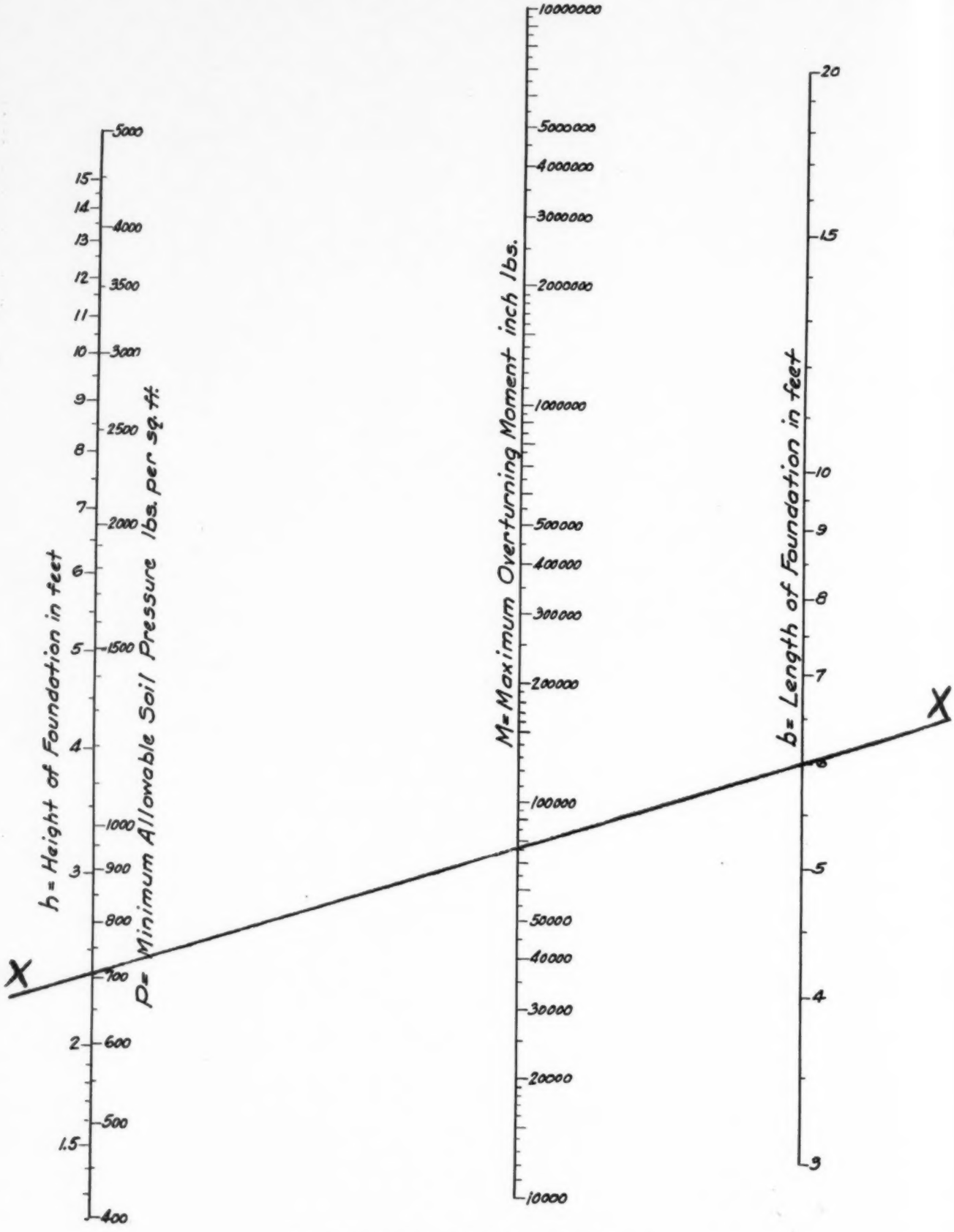


Fig. 12—Foundation for double column pipe support

equation. An explanation of its use in designing foundations for single column pipe supports is given by the following example:

Design a foundation to resist an overturning moment of 93,120 in.-lb. Assume the height of the foundation to be 4 ft.

Draw a straight line "X-X" intersecting "4 ft" on the h scale, and "93,120 in.-lb" on the M scale. Read on the b scale the length of one side of the square, which in this case is 4.3 ft. The size of the foundation necessary will then be 4 ft deep by 4.3 ft square. The minimum soil pressure required to support the foundation can be read on the P scale at the point of intersection of the "X-X" line, which is 1200 lb per sq ft. Soil pressure is based on the load of the structure plus the weight of the concrete multiplied by two as defined in the above equation. This is due to the tipping action of the foundation about its neutral axis set up by the overturning moment.

For double column supports a rectangular foundation as shown in Fig. 2 is suggested. This arrangement simplifies design and erection, and reduces cost.

It is assumed that the average foundation is 3 ft wide, and that the length and depth varies with the distance between the columns and the overturning moment. Fig. 12 was constructed on the basis that all simple foundations of this type can be made 3 ft wide; for other widths it will be necessary to calculate the size with the following formula. It will be noted that as the width increases or decreases, the length and depth will vary proportionately. By equating force of soil pressure on the foundation equal to the weight of the foundation:

$$W = 150 \times 3 \times hb = P \times 3 \times b/2$$

and equating moments:

$$M = 12 \times W'b/6 = 900hb^2$$

where:

W = Weight of the foundation, lb
h = Height of the foundation, ft
b = Length of foundation, ft
P = Minimum soil pressure, lb per sq ft, required to support foundation
M = Overturning moment, in.-lb
150 = Weight of gravel concrete, lb per cu ft
3 = Constant for width in feet if the nomograph of Fig. 12 is used for calculations. If widths other than 3 ft are used it should be changed accordingly, and the problem calculated with the formula.

An explanation of the use of Fig. 12 is given in the following example:

In the case of double supports the only overturning moment which affects the foundation is that caused by wind, since the support of the dead load is assumed to be concentric on the supporting columns. Therefore, from the example above, the moment caused by wind, $F + F_1$, only is considered. $F + F_1 = 53{,}760 + 22{,}560 = 76{,}320$ in.-lb.

Design a foundation to resist the moment 76,320 in.-lb, the width of which is 3 ft. Since the supporting columns are spaced 3 ft on centers, the length of the foundation is assumed to be 6 ft. Determine the height and allowable soil pressure. Refer to Fig. 12. Draw a straight line "X-X," intersecting 6 ft on the b scale, and 76,320 in.-lb on the M scale. Read on the h scale 2.4 ft, which is the height of the foundation. The allowable soil pressure is read on the P scale, 710 lb per sq ft.

Saves 16% Fuel by Modernizing Apartment Heating

TALL heating stacks, though necessary at times, frequently result in high fuel bills due to surplus draft when not required. A condition of this sort recently came up in connection with a 16 story apartment building in New York City.

The owner, an insurance company which took over the building under foreclosure, observed what seemed to be excessive fuel bills in the apartment's records. In fact, some 775 tons of rice coal were required annually. One of the first remedial steps was conversion of the system to vacuum, effected through the installation of a vacuum pump, pipe joint tightening, packing, some rearrangement of piping, and other procedure.

There are two 175 hp tubular boilers operating at 10 lb maximum pressure and a smaller unit of the same type used chiefly for water heating. In winter all three boilers usually ran full blast. At other times one of the large boilers was shut down. The stack is 180 ft high and draft was more than adequate under maximum requirements. When one boiler was shut down the boiler room staff never seemed able to reduce stack draft so that draft conditions were ideal for the units in service.

A counterweighted, balanced automatic smoke breeching damper was installed which is operated according to barometric pressure to maintain about ¼ in. over-grate draft, kept practically constant despite atmospheric changes. The damper swings open to short circuit boiler room air to the stack when natural stack draft is too strong and closes, or partially closes, when stack draft is weak. The ash pit doors are wide open at all times.

The contractor who made the installation states that since the improvement, coal consumption has been reduced to 650 tons. The owner's representative adds that whereas many apartments adjacent to the heating stack were abnormally hot, now they are cool and tenant complaints have ceased. Fly ash, formerly a nuisance, also has ceased to annoy. Cost of the damper installation was earned in full the first season of the modernization, fuel saving being 16 per cent.—R. C. NASON.

Boiler and Mechanical Horsepower

Many find the relationship between a boiler horsepower and the horsepower of an engine or motor confusing. Surprising as it may be, a boiler hp is 13.2 times as great as a mechanical hp. Here are the figures:

One boiler hp = 33,472 Btu per hr.
One mechanical hp = 2,546 Btu per hr.

The reason for this difference is that in the days when boilers and engines were first made and used, a 100 hp boiler was called so because of its ability to supply enough steam to run a 100 hp engine. A 200 hp boiler could furnish enough steam to run a 200 hp engine, and so on.

It is evident that when one boiler horsepower produced one mechanical horsepower the efficiency of conversion was only $1 \div 13.2 = 7.6$ per cent. In other words, only 7.6 per cent of the heat energy in the steam was converted into work. Today, efficiencies are much greater. According to my files the highest reported record is 27 per cent.—W. F. SCHAPHORST.

Acme.

AFTER *the* FLOOD

Restoring Equipment to Service

By **Samuel R. Lewis***

THE evils which can follow submergence of heating, piping or air conditioning equipment in muddy water pursue a long and devious path, particularly because of the necessity of restoring service quickly after the flood has passed.

It is possible, usually, to wash out the mud from the interior of boilers, piping, tanks, pumps, etc., and thus to restore a measure of cleanliness rather rapidly. It is not possible, however, to remove the water from the brick work of boiler settings, from the windings of electric generators, motors, and electric control devices without a comparatively long drying process.

Brick work and concrete saturated with water and then heated quickly will be torn to pieces by the rapid expansion of the water and by the steam. The windings of electric apparatus must be water-free before the usual energy is applied, as otherwise the moisture will short circuit the windings and burn them out with resultant heavy expense for re-winding. Probably the best procedure is to send the armatures and coils from large motors to an electrical manufacturer's plant where they can be baked dry under controlled temperature conditions, and where they can be proved ready for service without danger of damage. Where large heavy generators have submerged it is possible to dry them out in place, using fan-blown heated air, but the process is a tedious one, and the temperature of the air must be limited.

There is some advantage in buildings liable to submergence in the use of belted small electric motors for fans, pumps, and the like, since these usually can be replaced quickly with borrowed temporary substitutes while the original motors are rehabilitated.

Of course any competent custodian will, after a flood, wash out all shaft bearings to be sure that no grit has contaminated the grease. The oil of bearings which use oil, being lighter than water, will have been replaced by dirty water, and of course this must be corrected.

There is nothing to be done about water soaked boiler masonry except to dry it out very slowly with a small fire.

If the flood came so quickly that the fires could not be drawn and the boilers cooled down, it is advisable, particularly with cast iron boilers, to apprehend cracked castings and other leaks due to the rapid localized contraction following sudden cooling by flood waters. A wise precept no matter what kind of boiler may be in service is to have a standard hydrostatic test and a complete inspection made by the boiler insurance company.

The insulation of the boiler and hot piping will almost assuredly be so compressed and matted as to be useless, if indeed it has not fallen off. The insulation depends on its cellular quality for heat-barring effect, and the cellular quality of most insulation will be destroyed when it is water-soaked. It is quite likely that even if the insulation is not ruined the canvas jackets will mildew, and that some process of sterilization of the spores and then repainting of the canvas will be necessary.

Any tanks which could not be filled when the water rose around them must have exerted a powerful lifting effect and if not torn loose may have strained the pipe connections so that they will leak. Almost any buried fuel oil tank in flooded districts will endeavor to float up with the water, especially if only partly full. It is customary to anchor such tanks with concrete of sufficient weight to hold them down, even though they are empty, and it would be wise, in preparing for a flood, to fill the fuel oil tanks full of oil and to close off the valves so that the uncontaminated oil assuredly will be on hand after the flood is over. The oil will weigh less than the water it displaces, but the oil plus the weight of the tank and that of the superimposed earth probably will overbalance the lift of the water even without a concrete anchorage.

I will never forget watching a big brick cistern floating down the Missouri River at St. Joseph, Mo., during one of the periodical floods of the "Big Muddy." This round cistern evidently was nearly empty when the river washed the earth from around it, and although it was at least 15 ft in diameter it floated along in the stream just as easily as would a jug in a bath tub.

I remember also designing a low-lying boiler room for an institution in Marietta, an Ohio city subject to floods. This boiler room is reinforced and weighted down with water-tight walls extending above flood level so that it simulates a ship's hull run aground when the high water comes.

*Consulting Engineer, Chicago, Ill. Member of Board of Consulting and Contributing Editors.

New Uses for the Psychrometric Chart in Simplifying Air Conditioning Problems

By **William Goodman***

Part 3—Additional examples of the solution of air conditioning problems by the "psych" chart, and a discussion of cases where the sensible heat ratio is so low as to require reheating, are given here

EXAMPLE 5, published last month,[1] served to emphasize the fact that the quantity of air to be conditioned should not be selected until after the dry and wet bulb temperatures of the air supply have been determined by means of the heat ratio line. After the dry bulb temperature of the air supply has been determined, the quantity of air required can be calculated. Equation 1 (p. 87, February article) can be converted to the following form for quickly determining the required air quantity:

$$Q = \frac{H_s}{1.1\ (t_r - t_s)} \qquad [5]$$

where

Q = cfm of air to be supplied

H_s = Total sensible heat gain of the conditioned room in Btu per hr

t_r = Dry bulb temperature to be maintained in the conditioned room

t_s = Dry bulb temperature of the chilled air supply.

Table 2, which gives the cfm required per 1000 Btu of sensible heat gain, can be used even more conveniently than can Equation 5.

Example 6 illustrates the use of both Equation 5 and Table 2.

EXAMPLE 6—Assume the conditions of Example 5, except that the owner has waived the requirement of 1200 cfm of air.[2] Determine the condition of the air supply, and the quantity of air which must be supplied.

Solution—Referring to Fig. 8 (March issue) the point *D* represents the required condition of the air supply. The dry bulb temperature of the air supply should be 59 F and the wet bulb 57.3 F.

$$Q = \frac{15{,}200}{1.1\ (80\text{-}59)} \qquad \text{[from Equation 5]}$$

$$Q = \frac{15{,}200}{1.1 \times 21}$$

$$Q = 657 \text{ cfm}$$

The air quantity can also be determined with aid of Table 2. For a temperature rise of 21 F in the air supply, 43.1 cfm must be delivered for each 1000 Btu per hr of sensible heat gain.

$$Q = \frac{15{,}200}{1{,}000} \times 43.1$$

$$Q = 655 \text{ cfm}$$

Very often the air quantity, when calculated according to this method, will be smaller than that required by ventilation ordinances, or smaller than the quantity the designer feels, as a result of his experience with ventilation systems, should be supplied. If the air quantity is arbitrarily selected and insisted upon, the relative humidity in the conditioned room will be too high. The result of supplying too large a quantity of conditioned air to an enclosure is invariably too high a relative humidity. This is illustrated by the solution of Example 7:

EXAMPLE 7—Assume the conditions of Example 5, except that the owner is willing to waive the requirement of maintaining a 50 per cent relative humidity in the conditioned room. Find the relative humidity which will result in the room.

Solution—In Example 5, it was shown that the air supply must have a dry bulb of 68.3 F if a room temperature of 80 F is to be maintained with a 1200 cfm air supply. Also, it was stated that the characteristics of the

Table 2—Quantity of Air Supply Required for Various Rises in Dry Bulb Temperature

Rise in Dry Bulb Temperature of Air Supply, Degrees Fahrenheit	CFM Required per 1000 Btu of Sensible Heat Gain per Hr
6	150.8
7	129.3
8	113.1
9	100.5
10	90.5
11	82.3
12	75.4
13	69.6
14	64.6
15	60.3
16	56.6
17	53.2
18	50.3
19	47.6
20	45.2
21	43.1
22	41.1
23	39.3
24	37.7
25	36.2
26	34.8
27	33.5
28	32.3
29	31.2
30	30.2
31	29.2
32	28.3
33	27.4
34	26.6
35	25.9
36	25.1
37	24.5
38	23.8
39	23.2
40	22.6

*The Trane Co., LaCrosse, Wis. Copyright, 1936, by William Goodman.

[1] See HEATING, PIPING AND AIR CONDITIONING, March, 1936, pp. 147-150, and February, 1936, pp. 87-90 and 92.

[2] Example 5 read: A conditioned room which has a sensible heat gain of 15,200 Btu per hr and a latent heat gain of 4800 Btu per hr is to be maintained at a dry bulb temperature of 80 F and a relative humidity of 50 per cent. The characteristics of the air cooling equipment are such that the air leaving it has a relative humidity of 90 per cent. The owner has requested that 1200 cfm of outside air be conditioned and delivered. Can the designer comply with his request?

equipment were such that the air leaving it had a relative humidity of 90 per cent. Therefore, locate the point *A* in Fig. 9 at the intersection of 68.3 F dry bulb temperature with the 90 per cent relative humidity curve. Since the heat ratio is 0.76, lay off the line *A-C* at an angle of 21°-3′ with the horizontal.[3] The line *A-C* intersects the required room dry bulb temperature of 80 F at point *B*. The relative humidity which will result in the conditioned room is 65 per cent, as read at point *B*.

When Reheating Is Required

When very low relative humidities must be maintained, or when low sensible heat ratios are encountered, a sensible heat ratio line such as *A-B*, Fig. 10, when drawn on the psychrometric chart, may often fail to intersect the curves of 80 per cent relative humidity and higher. It is a characteristic of surface and spray type coolers that the air leaving them, while low in moisture content, is very nearly saturated, having relative humidities of roughly 85 per cent and higher. It is apparent, therefore, that commercial air conditioning equipment, while it can produce air of a low enough moisture content, cannot produce air of a low enough relative humidity to satisfy the requirements of a heat ratio line such as *A-B* of Fig. 10.

Sensible heat ratios so low that the heat ratio line will not intersect the curves of 80 or 90 per cent relative humidity are rarely encountered in comfort cooling work. Rooms in which people are exercising or dancing sometimes have low sensible heat ratios. The latent heat liberated by people when exercising is more than double the amount liberated when at rest, while the sensible heat liberated remains almost constant. Because of this the sensible heat ratio in such places as ballrooms may occasionally be so low that a steep heat ratio line will result.

[3]See Table 1, p. 148, March issue.

When a steep heat ratio line results, there is no remedy but to reheat the air supply from the point at which it leaves the conditioning equipment to some point on the heat ratio line. Such a reheating process is illustrated in Fig. 10. The point *C*, chosen at random on the curve of 90 per cent relative humidity, represents the condition of the air supply as it leaves the cooling equipment. The air supply is then reheated from point *C* to point *E* on heat ratio line *A-B*. Such a heating process takes place along a horizontal line of constant dew point temperature, since no moisture is added.

If the air supply were not reheated after leaving the conditioning equipment in the state represented by point *C*, it is obvious that the air supply would heat along a heat ratio line such as *C-D*. As a result, the relative humidity in the conditioned room would be higher than might be desired.

Reheating of the chilled air supply for the unusual conditioned room having a low heat ratio can be accomplished in several ways. It is not necessary to use steam with the entailed expense of operating a boiler during the summer months. The chilled air supply leaving the cooling coils can be reheated by mixing it with air having a higher dry bulb temperature. In actual practice, however, this method works out poorly.

A warm stream of air used for reheating a chilled air supply must be in such a state that the straight line connecting the "state point" of the warmer air with the "state point" of the chilled air leaving the cooling coils will intersect on the heat ratio line.[4] This is illustrated in Fig. 11.

A-B is the heat ratio line; *A* represents the condition of the room air. Let point *C* represent the condition of the chilled air leaving the cooling coils. Suppose that air from four different sources is available for reheating and that the air from each source is in a different state, represented by points *D*, *E*, *F* and *G*. Since the straight lines drawn from *C* to both *D* and *E* do not intersect

[4]This statement rests on the fact that the resultant condition of a mixture of air from two different sources can be found on the psychrometric chart by the following method:

Let point *A* on Fig. I represent the state of air from one source. Let point *B* represent the state of air from a second source. Draw a straight line connecting points *A* and *B*. Any point, such as *C*, which falls on the line *A-B*, represents the final condition of the mixture of air from the two sources. The location of the point *C* depends on the percentage of air from each source which is present in the mixture. For instance, if 50 per cent of the air in the mixture came from source *A*, and 50 per cent from source *B*, point *C*, representing the final condition of the mixture, would fall on the line *A-B* exactly half-way between points *A* and *B*. If only 25 per cent of the air in the mixture came from source *B*, point *C* would lie on the line *A-B*, one-quarter of the distance from *A* to *B*. In this case, point *C* would lie *closest to point A*.

The easiest way to locate *C* is to find the resultant dry bulb temperature of the mixture; point *C* will then lie at the intersection of the vertical dry bulb line, representing the final temperature of the mixture, and line *A-B*. For instance, Fig. I was drawn for the following conditions: Outside air, having a 95 F dry bulb and 76 F wet bulb temperature is to be mixed with room air having an 80 F dry bulb and 67 F wet bulb temperature. 25 per cent of the mixture is to consist of outdoor air and the balance of the mixture, or 75 per cent, is to be room air.

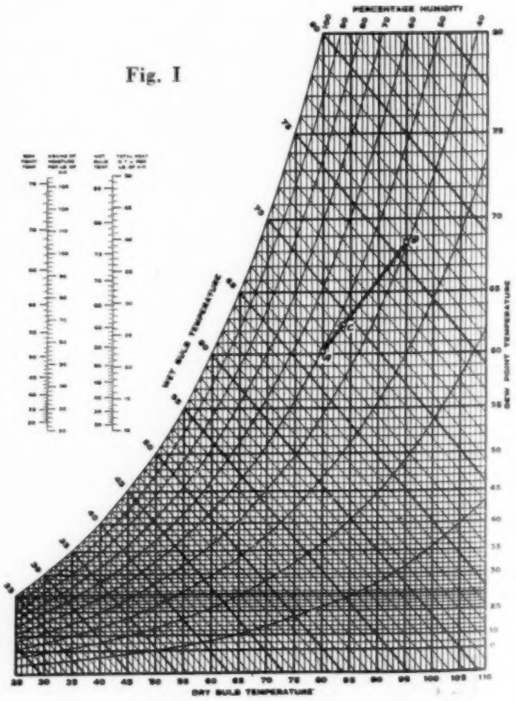
The final dry bulb temperature of the mixture can be quickly found as follows:

$$\begin{aligned} \text{Outside air} &= 0.25 \times 95 = 23.75 \\ \text{Inside air} &= 0.75 \times 80 = 60.00 \\ \text{Final dry bulb temperature of mixture} &= 83.75 \text{ F} \end{aligned}$$

Point *C*, representing the resultant condition of the air mixture is located on line *A-B* at the point where the vertical line of 83.75 F dry bulb temperature crosses line *A-B*.

Now referring to Fig. 11, the state point of an air supply for the conditioned room must lie on the heat ratio line *A-B*. This being the case, it is obvious that the resultant condition of an air mixture, consisting of air from two different sources, must intersect on the heat ratio line if the air mixture, when used as an air supply to the conditioned room, is to maintain the specified dry bulb temperature and relative humidity in the conditioned room.

Fig. I



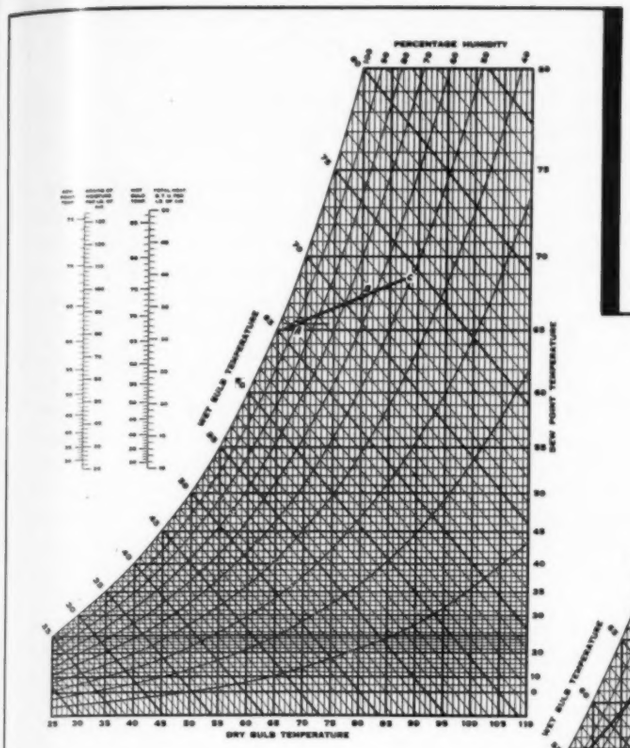


Fig. 9—Finding the relative humidity which will be maintained in a room, other conditions being given, is the subject of Example 7; the solution is shown here

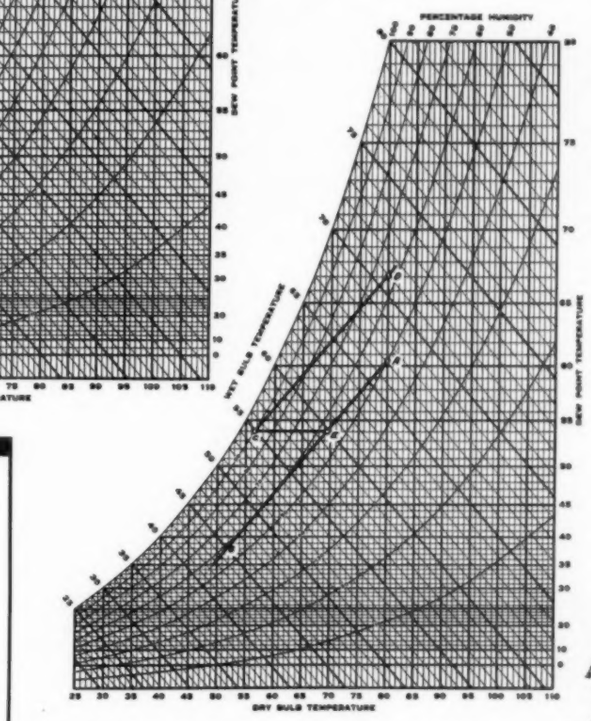


Fig. 10—When a steep heat ratio line such as *A-B* results, reheating is required. Such a process takes place along a line of constant dew point temperature, from *C* to *E*. If the air supply were not reheated after leaving the conditioning equipment, it would heat up along a line such as *C-D*, giving a higher relative humidity in the conditioned room than might be desired

the heat ratio line *A-B*, it is obvious that air from these sources cannot be used. The straight lines drawn from *C* to *F* and *G* do intersect the heat ratio line *A-B* and therefore air from these sources will serve satisfactorily.

In most air conditioning installations, air for reheating purposes can be obtained from but two sources, return air from the conditioned room or outdoor air. Air from the former source cannot be used when reheating is required because of a steep heat ratio line, and air from the latter source is unsuitable for this purpose.

Return air from the room, as represented by the point *A*, cannot be used since the point of intersection of the lines *A-C* and *A-B* is the point *A* itself. Under these conditions, an infinite quantity of air would have to be supplied in the conditioned room. Often the line connecting the point representing the state of the outside air, as *E* of Fig. 11, with point *C*, will not intersect on the heat ratio line. Even where the connecting line does intersect the heat ratio line, outside air may be unsatisfactory for use as a reheating medium, for (1) there is no assurance that the outdoor air will be in such a state, a major portion of the time, that it can be used for reheating; and (2) the introduction of outdoor air into a conditioned room, without first cooling and dehumidifying it, results in a rise in the relative humidity in the room. This can sometimes be avoided by providing an additional conditioned air supply to care for the added sensible and latent heat load of the room due to the introduction of outside air. However as a result of introducing the unconditioned outdoor air directly into the room, the sensible heat ratio of the room will be lowered still more, thus aggravating the condition. The effect of introducing unconditioned outdoor air

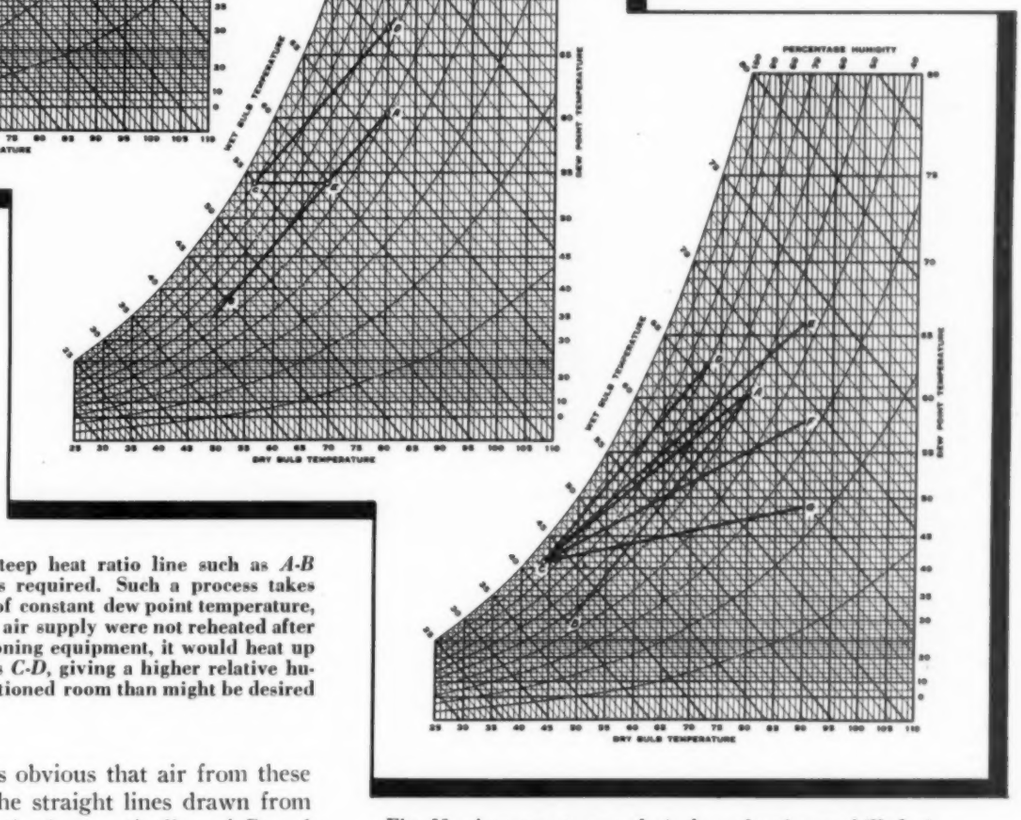


Fig. 11—A warm stream of air for reheating a chilled air supply must be in such a state that the straight line connecting the state point of the warmer air with the state point of the chilled air will intersect on the heat ratio line

into a room, insofar as the temperature and relative humidity of the conditioned room are concerned, is exactly the same whether the outdoor air is delivered alone or mixed with conditioned air before being introduced into the room.

Under these circumstances, there must be an actual addition of sensible heat to the chilled air supply. Two excellent methods are: (1) Warm water leaving the condensers may be circulated through a coil in the path of the chilled air leaving the cooling coils. (2) The so-called "run-around" cycle. These will be discussed next month.

Piping at Boulder Dam

By **Carleton W. Campbell***

LIKE everything else about the Boulder Dam project, the piping requirements are unusually large and interesting. There is in all a total pipe weight to be installed of about 6,700,000 lb, including fittings, ranging in size from the 30 ft penstocks down to ¼ in. copper oil lines and including over 3,000,000 ft of 1 in. cooling pipe. In addition to the penstock drawings, the piping required approximately 350 drawings covering general plans, diagrams, layouts and details.

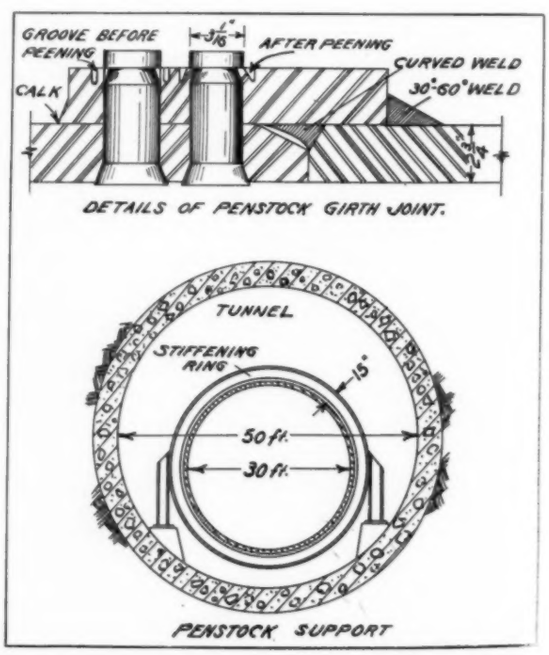
The penstock system is a giant piping project in itself. There are four main headers 30 ft in diameter with a maximum wall thickness of 2¼ in., made of high tensile strength plates. Each header has four 13 ft diameter branches to serve the turbines. Just below the last branch, each main conduit is reduced to 25 ft diameter and continues on down to a complicated manifolded outlet works controlled by large needle valves. The entire system, under full head of around 500 ft, has a total discharge capacity of 120,000 cu ft per sec.

This system requires about 4375 lineal feet of 30 ft diameter pipe weighing an average of 11,220 lb per ft, 1760 ft of 25 ft pipe, and 5550 ft of 13 ft pipe. The 30 ft pipe is made up into 30 ft lengths each having a 15 in. stiffening ring around its center by which it will be supported by brackets that bear on concrete piers in the tunnels. The lengths have a butt strap welded on one end to form a bell end for joining to the next length. There is also a reinforcing "tire" welded around each length near the end opposite the bell. Working pressure will average 225 lb per sq in.

For the power house piping, over 40 hanger drawings were prepared so that along every pipe line there would be the proper hanger fittings cast into the concrete. The slotted channel type hanger is used mostly, and where there is a large, heavy line or heavy fittings to be hung, "U" bolts are also cast into the concrete for chain-block anchorage, making it possible to hang the entire job without the aid of scaffolding. Another time-saving factor is that each and every piece of fabricated pipe, fitting, gasket, and even every set of bolts for flanged unions is numbered on the drawings and shipped from the various factories supplying this material numbered just like the drawings. This careful planning of hangers and numbering of all pieces is estimated to save from 2 to 3c per lb in erection cost.

Next in size after the penstocks is the cooling water system for the generators to deliver about 90,000 gpm and unique in that no pumps are involved. High pressure water taken from the penstocks energizes large eductors that pick up water from the tailrace, the mingling of the high pressure water and the slow pick-up water producing an average pressure and velocity suitable for the cooling system and eliminating motors, pumps and reducing valves. The energy of the penstock water also is used directly for service requirements in energizing the large eductors, two of which are installed in the discharge tubes of each turbine. These are for the purpose of un-watering the turbine draft tubes below the water level in the tailrace, for repairs. Gates can be closed to shut out the tailrace and the eductors in each tube will have a combined capacity of 3 cu ft per sec of leakage water and have the advantage over centrifugal pumps that they will handle mud and sand without damage and will not lose their prime.

*Mechanical and Industrial Engineer, Denver, Colo.



Author's sketch of penstock details showing how a bell end is formed of metal of the same thickness as the pipe by welding in the fabricating shop. On the job, the pipe is cooled somewhat below working temperature and the bell heated for a shrink fit. It is then pinned together by a double row of headless undercut pins around each of which is an annular groove permitting metal to be peened into the undercut pins. Supporting brackets are welded to the stiffening rings on the job

Handling Fuel Oil

Part 5—Metering, or Feed Regulation

By **Kalman Steiner***

THE final operation in a fuel oil transmission system is that of metering, or regulating the feed to the nozzle or atomizer. There are two distinct phases to this operation, the first—which is the one to be considered in this paper—being the mechanism of hydraulic regulation of flow; the second is the method of actuating this mechanism and hence of proportioning the fuel flow in accordance with load or process demands.

Types of Valves Used

The first and still the commonest means employed for regulating oil flow is the needle valve, both in the angle and straight-through forms; for light oils it is a fairly satisfactory valve. Many forms are made with indicating devices to show the amount of rotation from the closed position. For heavier oils, however, they exhibit a tendency toward flow restrictions, probably because of film formation. In the needle valve, the space through which the fluid flows is distributed as a ring between the two concentric circles of the valve stem and the valve seat. This ring very often is so narrow that the viscous oils tend to cling to both sides, and if the surface tension is sufficiently strong, the resultant film which is gradually stretched across the opening slowly diminishes the flow until it stops completely. Operators often try to overcome this by raising the oil pressure at the pump, but that is exactly the wrong thing to do. Higher pressure merely increases the speed of flow, so that the annular opening of the needle valve must be even smaller for the same quantity, and the tendency toward film formation increases. To correct diminishing flow in a needle valve, drop the pressure to the lowest possible point so that the valve may be opened as wide as possible for the permissible quantity passed. This will retard and sometimes overcome the tendency toward film formation. Sometimes the same diminution of flow occurs because of colloidal sediment which cannot be removed at the strainers; the same rule holds—running at the lowest possible pressure to prevent the sediment from depositing on the valve seat, which is the point of greatest restriction after the strainers.

Globe valves are seldom used in oil systems both because of the high pressure drop which they induce in the line, and because the slight clearance between the disc and seat gives rise to the same film formation or sediment deposit as with needle valves. Gate valves are, of course, hardly adaptable to control but are commonly used as shut-off valves.

A popular adaptation of the needle valve is the metering, or V-notch, valve, in which the stem is a cylinder fitting closely through the seat opening. When the stem is turned completely down, the upper end of the cylinder, which broadens out into a cone, brings the seat surface into tight contact with this cone and flow ceases. Cut longitudinally into the surface of the cylinder is a V-shaped notch which has a varying cross-section. Turning the valve stem therefore exposes a varying cross-section of the "V" for flow of liquid, so that close control can be had. The same amount of opening as would exist in a needle valve for the same flow under identical conditions is therefore condensed from a ring into a triangle so that the smallest dimension of the opening is much greater and the tendency toward film formation or sediment deposition is reduced. This V-notch valve serves well with most industrial fuels except the very heaviest.

Orifice Plates

Leaving the realm of valves, the next sort of control device is the orifice plate. An orifice offers the advantages that no working parts are needed in the device itself, and that flow through it can be controlled by simply varying the pressure behind it. The flow is independent of film restrictions because of the full circular opening. Against the orifice as a regulating device are the facts that with any given orifice the flow can be varied only to the maximum and minimum limits set by available pressure variation; beyond these limits, it becomes necessary to use another orifice plate, with a larger or smaller orifice as the case may be. Orifice plates are also occasionally used with standpipes, so that the head acting on the upstream side is varied by raising or lowering the level of liquid in the standpipe. This method is not easily adaptable to industrial use.

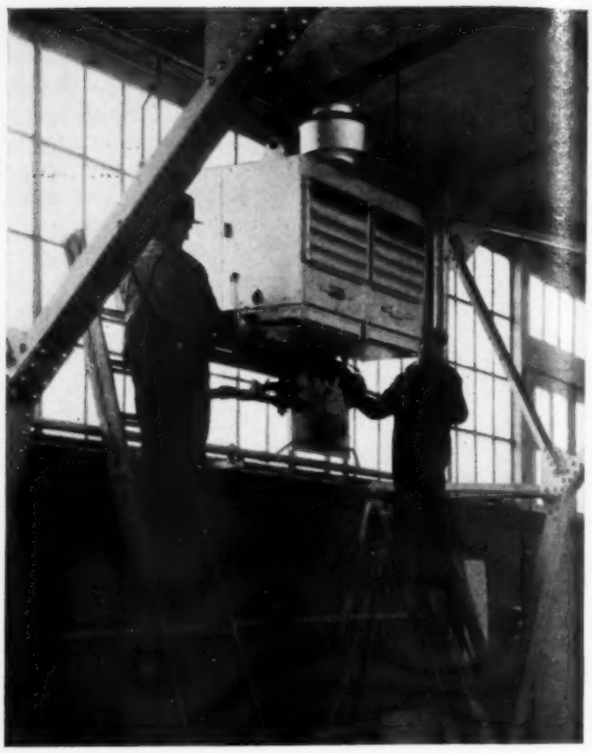
Other Flow Regulators

These two methods of control embody oil pressure as one of the variables, for regardless of the valve or orifice used, flow is determined by the pressure head existing on the upstream side, or, more properly, by the pressure differential between the upstream and downstream side, which is a function of the upstream pressure. Since pressure regulators are not as yet perfect in their regulation, it follows that metering devices dependent upon them will reflect a variation in flow equivalent to the variation in pressure. Changes in oil viscosity will also cause changes in delivery through a valve or orifice. Hence, a regulator independent of oil pressure will eliminate that variable, and at least one form is available which also eliminates variation due to viscosity changes.

One commercial form of such a flow regulator depends for its operation upon the uniform and unvarying delivery of a displacement pump such as an internal gear type, regardless of changes in the fuel oil's viscosity, temperature, or other physical attributes. This uniform delivery is taken into the central cylindrical bore of the uniflow valve, as it is called. There are two outlets from this central bore, one leading back to the storage tank, the other to the burner. A piston working back and forth in this bore will vary, by means of a screw adjustment, the area exposed by the two outlets of the central

*Chief Engineer, Consumers Petroleum Co., Chicago, Ill. Copyright, 1936, by Kalman Steiner.

Sixty Gas Fired Units Heat Pier Exhibit Space



Installing the pressure regulators which serve each of the 60 twin unit heaters for the 67 ft by 2300 ft exhibit space. Gas pressure, reduced from 6 lb to 6 in. at sub-headers, is further reduced at the burners to 3 in. to assure uniformity of operation

ONE of the largest unobstructed exhibit spaces in the world—a space 67 ft wide and 2300 ft long, on Chicago's Navy Pier—is now being heated by 60 twin gas fired unit heaters. The unusual shape of the exposition hall, especially its extreme length, dictated against a central heating plant. A factor influencing the choice of equipment was the comparative narrowness of the hall, making it undesirable to encroach on floor space.

The heaters, each twin unit with a rating of 400,000 Btu per hr, are spaced 40 ft apart along the south wall. Air is circulated by two squirrel cage rotary blowers, mounted on a single shaft, driven by a 1 hp motor at 600 rpm. Each twin unit will heat and circulate 5800 cfm of air.

The heaters are hung from roof members 10 ft above the floor, and a 4 ft by 1 ft cold air intake runs from each heater to within 3 ft of the floor. Each intake has a manually controlled damper so that inside or outside air can be circulated; except for unusually crowded conditions, it is expected that most of the air will be recirculated. It is contemplated that the fans on the heaters will be used during the summer for ventilating the exhibit hall, their capacity making it possible to change the air every eight minutes.

Design temperature was 70 F inside with —20 F outside. Controls on each heater make it possible to shut off one of the twin units, and thus heat only half of the air which is circulated through the unit in mild weather.

To secure an adequate supply of gas for the installation, The Peoples Gas Light and Coke Co. laid 7000 ft of gas main (3000 ft of 12 in. and 4000 ft of 6 in.) which carries gas at pressures between 2½ and 6 lb per sq in. Pressure is lowered to 6 in. at three sub-headers by reducing valves; each sub-header supplies 20 of the heating units, and each heating unit has a regulator which reduces the pressure at the burner from 6 to 3 in.

Gas is metered through a 35,000 cfh rotary orifice meter housed and kept at a temperature of not less than 40 F by a 30 gal automatic water heater with radiation connected and surrounding the meter.

The contractors were Robert Gordon Co. Heating of the space has already insured a number of conventions which would otherwise have been lost, it is said.—WINFIELD FOSTER.*

*The Peoples Gas Light and Coke Co., Chicago, Ill.

Handling Fuel Oil—

[*Concluded from preceding page*]

chamber. With any position of the piston, therefore, a ratio is determined between the outlet to the tank and the outlet to the burner. The discharge from the pump must therefore divide in conformance with this ratio, and since the discharge is a constant, regardless of the physical state of the oil, the feed to the burner is a constant.

Some devices utilize the uniform delivery of a gear type pump to establish the feed itself, by providing a means of varying the mesh of the gears. For any given mesh the discharge is a constant, and this discharge is used as the burner feed. In such cases the surplus from the main pump, ahead of the metering pump, is returned to storage. This method however implies the use of two pumps which is not always desirable.

A recent interesting development is a fuel unit for domestic oil burner use which embraces three or four elements of the pumping system (usually made by at least two different manufacturers) such as pump, strainer, pressure regulating valve, and sometimes a pressure gauge or vacuum gauge.

[This is the fifth of Mr. Steiner's five articles on handling fuel oil. Previous articles appeared in HEATING, PIPING AND AIR CONDITIONING, November, 1935, p. 538; December, 1935, pp. 575-576; February, 1936, pp. 91-92; March, 1936, pp. 145-146—THE EDITOR.]

PRACTICAL HEATING

By **Harold J. Taylor***

● Notes on Unit Heaters Unit heaters in themselves are quite immune to defects but trouble is often encountered due to improper installation, operation or maintenance. The following notes are the result of a wide experience in correcting such difficulties.

Dirt—Due to the recirculation of air, units may become clogged up with dust, grease, etc., which cuts down the heating effect. Air or steam, if available, may be used to blow the accumulations from the finned surfaces.

Check Valves—When two or more units are installed it is customary to use either traps or check valves or to use a wet return. If it is practical to connect to a wet return, do so, as I believe this results in a trouble-free and better working job.

Where check valves are used on the return of a dry return system, be sure they are installed at a point low enough (at least 10 in.) so that steam in the return line will not hold the check valve closed and air-bind the unit. To determine whether or not the unit is air-bound, get up at least a pound or so of pressure and with the motor turned off, run your hand over the entire surface of the unit. If it is not hot throughout then the unit must be air-bound. In keeping 10 in. or more below the unit with the check valve, the weight of condensate plus the steam pressure will open the check valve against the opposing return line steam pressure.

Between the check valve and bottom of the unit heater there should be installed a good quick vent valve, preferably of the float type. Keep in mind that most of the quick vent valves on the market will close off on pressures exceeding 10 lb. The quick vent valve should be extended up to approximately 20 in. from the opening of the return line where connection to vent is made.

Traps—When traps are used with unit heaters it must be remembered that the return line will have no pressure in it and the boiler will have to be protected against a condition which will prevent the condensation from returning to it because of the unequal pressure between the supply and return mains. Determine the water line difference and pressure drop and then decide what automatic means if any will be used to return the water of condensation to the boiler—boiler return trap, condensation, or combination condensation and vacuum pump.

Traps of ample capacity to handle the condensation when the units are starting up and the air temperature entering the units is very low should be selected. I would suggest, especially on large units, the use of combination float and thermostatic traps.

Where the supply to the unit is fitted with a gate valve and the return from the unit is connected into a wet return, a 45 deg check valve should be installed in the return line from the unit. This will prevent the water from the wet return backing up into the unit in the event the gate valve is shut off.

Electrical—It may be that the motor is wired for one type of current and is connected to a different power supply. In this case the speed of the fan motor is affected and the unit will not develop its rated capacity.

Motors should be oiled or greased at least once during the heating season. Do not over-oil or grease a motor.

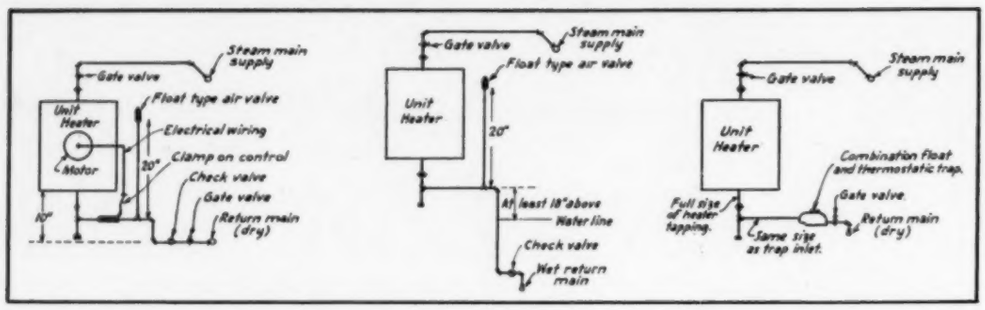
Multi-Speed Motors—It is often desirable to furnish motors of more than one speed. When a two or three speed unit is to be used, the capacity of unit should be based upon the second or low speed to deliver the normal sq ft of radiation required to heat the building, the higher speed being used for heating up periods. The boiler size is of course selected on the high speed delivery capacity of the unit.

Control—Where constant steam pressure is carried and even temperature is desired, install a temperature (thermostat) control which will automatically start and stop the motor to maintain a positive temperature. Depending on the type of job and location of the unit heaters, one thermostat may be used to control one or more units. The thermostat should not be in the stream of heated air; a logical location is usually near one of the unit heaters in the path of the return air.

When the steam pressure is not constant and manual operation of the motors is not practical, then I would suggest the installation of a clamp-on control on the return line from the unit heater which will automatically keep the motor running only when the unit is full of steam. In case of steam failure the control will shut down the motor, preventing the blowing of cold air. I have found need for the clamp-on control to prevent boiler breakage on jobs where the units are turned off for the night. With the control, power may be left on at all times and if during the night the boiler should commence to make steam from a banked state (owing to high wind, etc.) the units will start up and prevent extreme boiler pressures which would cause the safety valve to discharge steam and water to a point where damage to boiler might result. I have personally been on three jobs where the boilers were damaged from this apparent cause. Since the installation of the clamp-on control on these particular jobs, no trouble has been encountered with the steam boiler and over-pressures at night.

Boiler Load—Unit heater manufacturers list the equivalent direct radiation (EDR) capacity, Btu output and lb per hr of condensate under different steam pressures and varying initial air temperatures. With this information at hand it is an easy matter to figure the boiler capacity required to handle the load, remembering that a pound of steam is equal to 4 sq ft of cast iron column or tube radiation under standard conditions and 960 Btu's are equal to 1 lb of condensate. The boiler size must be based on the highest condensate rate of the unit; in other words a unit that will condense 166 lb of steam per hr at a steam pressure of 5 lb, initial air temperature of 70 F, and a final air temperature of 130 F will be equal to 644 sq ft E.D.R. load under average conditions. If we subject this particular unit to an initial air temperature of 40 F under the same conditions in

*Contracting Engineer, Detroit, Mich.



These sketches indicate proper methods of installing unit heaters, as outlined in the text

regard to steam pressure, the unit will condense 203 lb of steam and the final temperature will be 110 F. In this case 203 lb of steam multiplied by 4 equals 812 sq ft E.D.R. load under abnormal conditions. Our boiler load in this case should be based on 812 sq ft. Looking back to our basis of boiler load of 664 sq ft it is seen that if a building is not kept up to a normal temperature 24 hr per day, 7 days per week, the boiler load must be figured on the highest condensing rate of the unit heater.

Hot Water Jobs—Unit heaters are used on both gravity and forced hot water jobs. Care must be exercised to check the unit heater ratings on the lower average temperature of hot water; in other words, it generally requires a larger unit to heat a given space by hot water than by steam, dependent, of course on the water temperature. The heating elements of most unit heaters are designed primarily for operation on steam and the application to hot water is not always satisfactory. Purchasers should check up on this point.

Unit heaters may be installed in connection with direct radiation and this combination affords a very satisfactory means of heating. If the amount of radiation installed on a job is found to be short, a unit heater figured for the size to make up the deficit is a good means of correcting the difficulty, providing a unit heater is adaptable to the heating system.

Summer Use—During summer months a unit heater may be operated to move the air within the building, creating a cooling effect. This practice is used in many installations and the cost of operation of the units is very low.

Some makers of unit heaters also make unit coolers, both for chilled water and direct expansion; the chilled water units are usually designed so they may be supplied with either hot water or low pressure steam for heating. This type of installation requires additional valves so that the unit may be changed in its operation from summer cooling to winter heating; also, the unit must be provided with a drain connection to carry away the condensation from the chilled coils. The louvres on front of the unit must be reversed from that of heating in order to prevent cold drafts.

Units designed for cooling with direct expansion refrigerants cannot be used for heating purposes unless they are built with separate coils or elements for heating and cooling.

Two Well-Known Buildings to be Air Conditioned

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***Left*—Federal Reserve Bank, Chicago. *Right*—The Wrigley Building, on Michigan Avenue**

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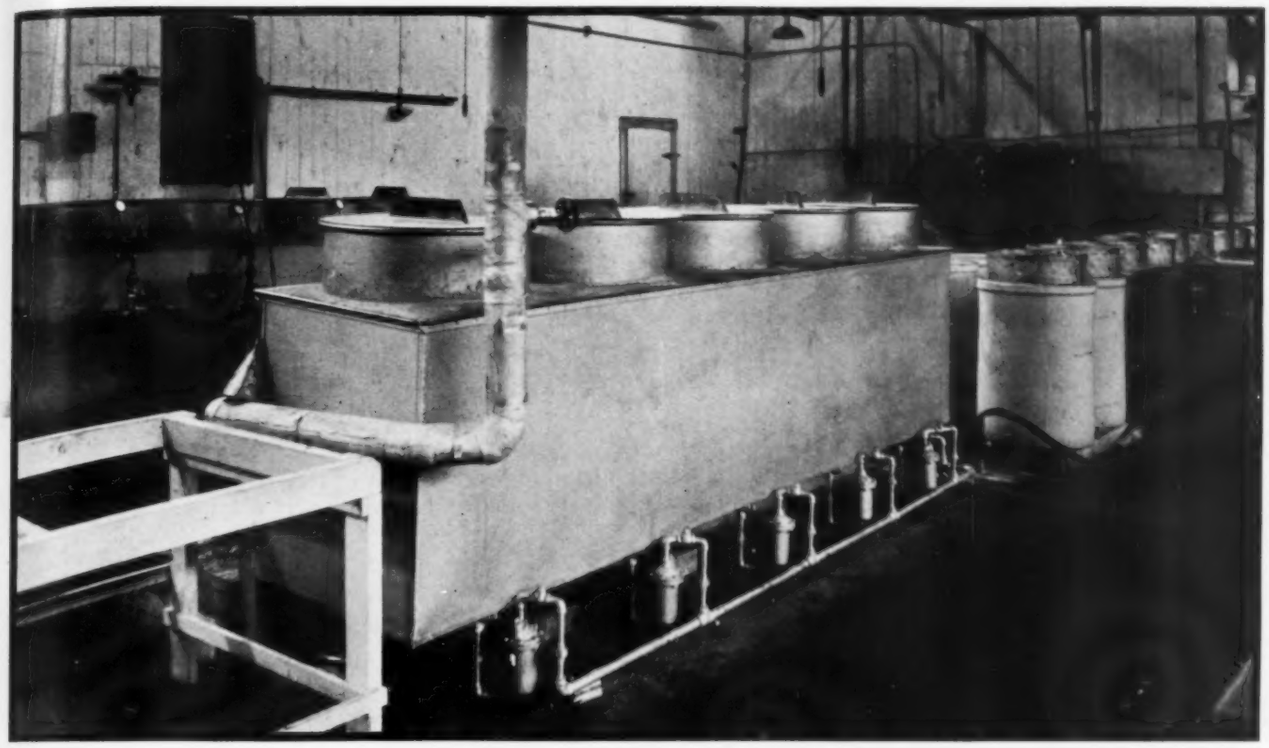
Two big Chicago air conditioning jobs have recently been announced, one for the Wrigley Building at the Michigan Avenue bridge, and the other for the Federal Reserve Bank Building in the heart of the La Salle St. financial district.

At the Wrigley Building 120,000 sq ft of space is to be air conditioned. The refrigeration will be furnished by centrifugal water vapor machines, a 350 ton unit to be installed now, with provisions for increasing the capacity of the system to 1050 tons later.

The system will be a coil job, and the same piping will be used for the circulation of hot water for winter air conditioning. Reader Joseph F. Darlington of Winston & Co. is engineer for Wm. Wrigley Jr. Co.

The Federal Reserve Bank job's sole aim is increased comfort and efficiency of employees, as the space to be conditioned is occupied entirely by the owner.

Contractor for each of these installations is the Kroeschell Engrg. Co.



Five steam jacketed kettles, individually trapped, at the Soybean Products Co.

Condensate Removal from Cooking Kettles

Cooking Time, Steam Consumption, Cut by Proper Trap Selection and Piping

STEAM jacketed kettles have been used for many years for cooking all kinds of products from tomato puree to candy, yet there is still discussion as to the conditions under which a kettle will give the most efficient results with minimum steam consumption. Most operators have felt that they had two alternatives—permit the steam to blow through a cracked valve in order to speed up cooking, or be content with slower cooking time in order to save steam by trapping out the condensate.

Quick cooking is essential in some processes and of secondary importance in others. For example, tomatos must be cooked in the shortest time possible to preserve color and flavor. Custards and like materials having a milk base, as well as tomatos, must be brought to a boil quickly in order to avoid a deposit on the heating surface of the kettle which greatly reduces the heat transfer. But in a hotel kitchen no great harm is done if the soup requires 15 instead of 10 minutes to come to a boil.

By **John W. Hieronymus***

*Engineer, Barrett-Christie Co., Chicago, Ill.

To obtain performance data on steam consumption of and condensate removal from cooking kettles, extensive tests have been made[1] on jacketed kettles ranging from 15 to 250 gallons capacity. It was found that with traps properly selected to handle both the air and the condensate, no steam was wasted and there was no increase in cooking time. The following paragraphs briefly describe the tests.

Into a kettle, Fig. 1, was weighed 417 lb (approximately 50 gal) of city water at 43 F. Into the steel drum, 231 lb of water was weighed and its temperature taken. With cold water in both the kettle and the steel drum, the main steam valve was opened. Readings were taken at the end of ½ minute, 1 minute, 1½ minutes, 2 minutes and at the end of each minute until the water in the kettle reached the boiling point. The readings included steam pressure in the main supply line, in the line to the kettle and in the line between the kettle and the steam trap; steam temperature in the line to the kettle, temperature of water in the kettle, con-

[1]By Armstrong Machine Works, Three Rivers, Mich.

Less data than one would suspect (considering the extensive use of steam kettles for cooking) have been available upon the proper methods of condensate removal from steam jacketed kettles, proper piping connections, and steam requirements of such equipment. The author, who has had considerable contact with installations of this kind in a number of plants, presents here information to answer such questions, several of which have been received from readers

densate temperature in the line between kettle and trap, temperature of condensate and water in the steel drum at the end of the test, and weight of the drum and water.

In all, 39 tests were made with water and steam conditions approximately constant but with different methods and different sizes of traps for draining the steam jacket. Some of the tests were run only until the water in the kettle would "break" or start to boil violently while others were continued for several minutes after the break for evaporation tests.

The average results of the most important tests were confirmed by similar tests on 15 gal and 250 gal kettles at steam pressures ranging from 10 lb to 90 lb gauge. From these tests, the following conclusions are drawn:

1. Traps do not increase cooking time.
2. Less steam is required to bring water to the boiling point when the proper trap is used.
3. Less steam is required to evaporate 1 lb of water when the proper trap is used.
4. The total evaporation from the kettle per minute is greater when the proper trap is used.

Supply and Condensate Piping Should Be Ample Size

The 50 gal test kettle happened to have a ½ in. steam inlet. Accordingly, the kettle was first connected with a ½ in. steam supply line but the friction in this line caused excessive pressure drop through the kettle. For example, when the steam was supplied at 40 lb pressure, the pressure in the kettle dropped to 14 lb gauge but when the ½ in. line was replaced with a 1 in. supply line, the kettle pressure seldom fell below the line pressure except when the largest traps were used; even then, the pressure drop did not exceed 25 per cent.

If the condensate line is too small the pipe friction will decrease the pressure drop through the trap which also cuts trap capacity very materially. A 1¼ in. trap on a 250 gal kettle was connected to a length of 1 in. pipe with six ells. With this hookup, the trap appeared to discharge continuously. When the 1 in. line was replaced with a 1¼ in. line having two ells, the trap operated intermittently, which proved that friction in the discharge had been cutting trap capacity.

Imperative to Remove Air

Probably the most important fact ascertained during these tests was that it is imperative to remove completely all the air in the jacket of the kettle. A trap which is too small will allow sufficient air to remain in the kettle to reduce the heat transfer to the extent that the trap will have an intermittent discharge. This intermittent discharge could be very misleading as it would naturally indicate that the trap was of ample size. But the tests showed that the steam temperature in the jacket of the kettle was not the temperature corresponding to the steam pressure used, due to the air remaining in the jacket.

The heating value of 1 lb of steam depends to a great extent on the steam being in a pure condition; steam diluted with air has a lower temperature than "pure" steam. Table 1 shows the reduction in temperature occurring in steam mixed with various percentages of air. Under extreme conditions the presence of ½ of 1 per cent by volume of air mixed with steam will reduce the heat transfer efficiency by 50 per cent. Hence the importance of prompt and continuous air removal from steam jacketed kettles cannot be over-emphasized.

Steam Loss with Cracked Valve

A cracked valve may, if not opened too wide, approach the performance of a properly sized trap, but at its best will show a marked steam loss which in the period of a year will amount to considerable money, as indicated by Table 2. As it is impossible for the operator accurately to adjust the cracked valve for all con-

Table 1—Temperature Reduction Caused by Air at Various Pressures

Gauge Pressure Lb per Sq In	Temperature of Steam with No Air Present, Deg Fahr	Temperature of Steam Mixed with Various Amounts of Air (Per Cent Air by Volume)		
		10 Per Cent	20 Per Cent	30 Per Cent
10.3	240.1	234.3	228.0	220.9
25.3	267.3	261.0	254.1	246.4
50.3	298.0	291.0	283.5	275.1
75.3	320.3	312.9	304.8	295.9
100.3	338.1	330.3	321.8	312.4

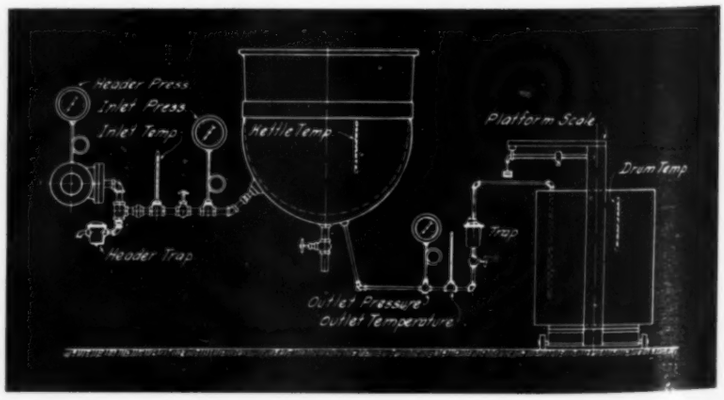


Fig. 1—Test set-up for determining effect of condensate drainage on cooking kettle efficiency

Blow thru 1" pipe
Blow thru 1/2" orifice
1" Trap with thermic bucket vent
1 2 3 4 5 6 7 8 9
Time in minutes required to raise temp. of 50 gal water in kettle from 43 F to 212 F
Blow thru 1" pipe
Blow thru 1/2" orifice
1" Trap with thermic bucket vent
20 40 60 80 100
Pounds of steam required to raise temp. of 50 gal water in kettle from 43 F to 212 F
Blow thru 1" pipe
Blow thru 1/2" orifice
1" Trap with thermic bucket vent
.20 .40 .60 .80 1.00 1.20 1.40 1.60
Pounds of steam used per pound of water evaporated in kettle.
Blow thru 3/4" pipe
Blow thru 3/8" orifice
1" Trap with thermic bucket vent
2 4 6 8 10
Pounds of water evaporated per minute from kettle
100 Gallon kettle tests, 30 pounds initial steam pressure, 50 gal water in kettle.

Fig. 2—Test results

ditions, he must set it to handle the heavy surge of condensate which occurs at the beginning of the cooking. This setting is far in excess of that required after the first surge of condensate is taken care of. This large opening leads to an excessive steam loss accompanied by a decided drop in pressure in the jacket of the kettle. This drop in pressure reduces the rate of heat transfer and accordingly increases cooking time, for the heat transfer is in proportion to the difference in temperature which in turn depends upon pressure.

Table 2—Cost of Various Sized Steam Leaks at 100 Lb Pressure, Assuming Steam Costs 50 Cents per 1000 Lb

(Based on 24 hr per day)

Size of Orifice, In.	Lb Steam Wasted Per Month	Total Cost Per Month	Total Cost Per Year
1/4	835,000	$417.50	$5,010.00
3/16	470,000	235.00	2,820.00
1/8	210,000	105.00	1,260.00
1/16	52,500	26.25	315.00
1/32	13,200	6.60	79.20
1/64	3,400	1.70	20.40

For steam at 50 lb pressure, the waste is about 75 per cent of the above figures; at 20 lb, it is about 50 per cent; and at 5 lb, the loss is about 25 per cent.

Steam Requirements of Kettles

From the test data obtained, it has been calculated that after the liquid has been brought to the boiling point, the maximum heat transfer will be approximately 425 Btu per sq ft per hr per deg difference in temperature between the steam and the boiling liquid. In Table 3 this is converted into lb of steam per sq ft per hr, assuming a liquid temperature of 210 F and that only the latent heat of steam will be available for heating. If the boiling point of the liquid is above 210 F the amount of steam condensed per sq ft per hr will be reduced.

The area of a jacketed kettle in contact with steam is usually a half sphere, and in Table 4 the steam condensing area of jacketed kettles ranging in diameter from 18 to 46 in. is shown. The size of a jacketed kettle depends as much upon the height above the jacketed surface as it does upon the diameter; for example, one manufacturer lists 60, 70 and 80 gal jacketed kettles all 32 in. in diameter. Since the steam condensing rate depends upon the size of the condensing surface and the difference in temperature, it follows that in calculating trap sizes it is safer to use condensing areas than to use kettle capacities that have no direct bearing on the steam condensing surface.

Table 3—Steam Condensed Per Sq Ft of Jacketed Kettle Condensing Surface at Pressures from 1 to 100 Lb

Steam Pressure Lb	Steam Temp. Above 212 F	Btu per Hr	Lb of Steam Condensed per Sq Ft per Hr
1	6	2550	2.64
2	9	3825	3.96
3	12	5100	5.3
4	15	6375	6.63
5	18	7650	7.97
10	30	12750	13.4
15	40	17000	18.0
20	49	20850	22.2
25	57	24200	26.0
30	64	27200	29.3
40	77	32750	35.6
50	88	37400	41.0
60	97	41200	45.6
70	106	45100	50.3
80	114	48500	54.5
90	121	51450	58.1
100	128	54400	61.9

Table 4—Steam Condensing Area of Jacketed Kettles (Hemispherical Surface)

Diameter of Kettle in Inches at Top of Steam Jacket	Area of Condensing Surface, Sq Ft	Diameter of Kettle in Inches at Top of Steam Jacket	Area of Condensing Surface, Sq Ft
18	3.5	30	9.8
19	3.9	32	11.2
20	4.35	34	12.6
21	4.8	36	14.1
22	5.3	38	15.7
24	6.3	40	17.4
26	7.4	42	19.2
28	8.5	44	21.1
		46	23.0

Air Conditioning Installations in Houston

Supplementing data for some 40 other cities published earlier this year, the following tabulation shows the number of air conditioning installations and connected horsepower for Houston, Texas, for 1935, 1934 and total at the end of 1935. This information was obtained through the courtesy of E. F. Wilson of the Houston Lighting & Power Co.

Number of Air Conditioning Installations and Connected Horsepower for Air Conditioning, Houston, Texas

1935		1934		Total, Dec. 31, 1935, Including Prior to 1934, 1934, and 1935	
No.	Hp	No.	Hp	No.	Hp
46	2466.25	33	648.9	109	6770.35

It will be noted that, as with the data previously presented, the number of installations in 1935 was considerably greater than in 1934, and that the average size of last year's job was considerably larger than that of the 1934 installations. As in other cities, the great majority of installations were in commercial and public buildings.

Designing Vanes in Duct Elbows

A READER wishes to know, referring to the chart published in my book,[1] "Air Conditioning for Comfort," and reproduced here, how I would design intermediate vanes in a square duct elbow if the elbow were of reducing type. The sketch shows the problem and the solution.

I know of no absolute scientific rule for a special transforming elbow such as this. I have every belief that the following is a rational solution:

The average width of the elbow is $\frac{46+60}{2} = 53$ in. and the average height is $\frac{18+20}{2} = 19$ in. The 53 in. vertical line can be extrapolated on the chart and evidently would intersect the No. 15 diagonal just after crossing the 19 in. horizontal. Thus there would be 15 blades. The blade radius would be about 4 in., the lip extension 2⅜ in., and the blade spacing would be that to give one more space than the number of blades at right angles across the duct.

The intersection of the vane centers with a diagonal line drawn across the elbow would determine the spacing for the other leg of the unsymmetrical duct.

It seems to me that the only defensible solution for determining the number of blades is that which assumes that the cross-sectional area at the point where the vanes are located is proportional to the average area of the tangents which enter the curve.

When the duct is wider than the dimensions given on the chart, the vane spacing can be determined from the chart by using half or some other proportion of the width. Thus in the present case instead of extrapolating, one could assume that the duct was 53/2 = 26½ in. wide and 9½ in. high. These lines would intersect below the same 15 blade diagonal, determining the number of blades as 15 and the number of spaces as 16. For the radius and lip extension the full duct height of 19 in. on the chart must, of course, be used and the reading at the right checks out as 4 in. for blade radius and 2⅜ in. for lip extension.—SAMUEL R. LEWIS.*

[1]Published by Keeney Publishing Co., Chicago, Ill.

*Consulting Engineer, Chicago, Ill. Member of Board of Consulting and Contributing Editors.

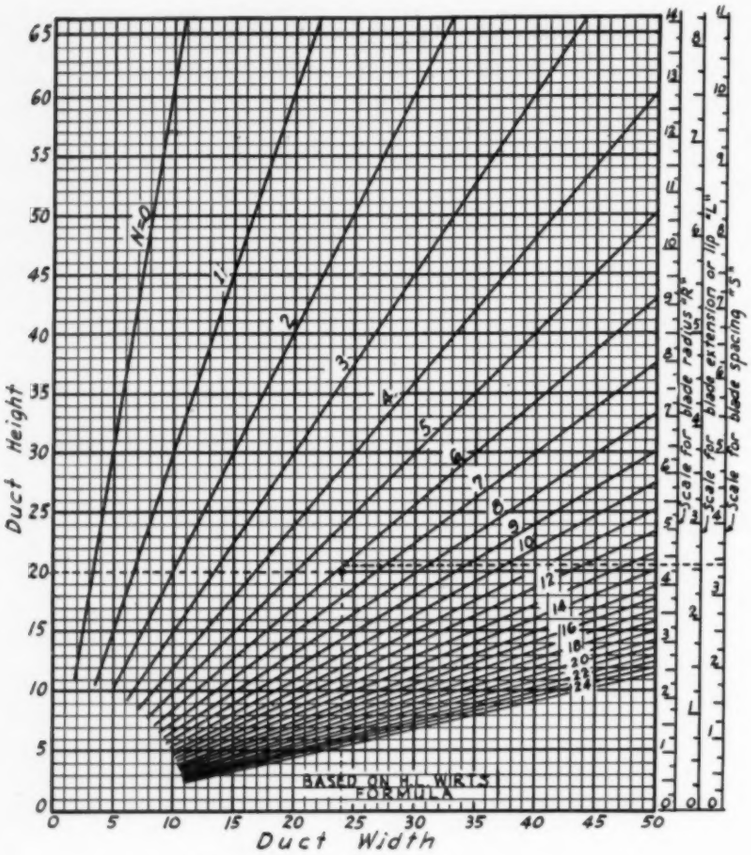
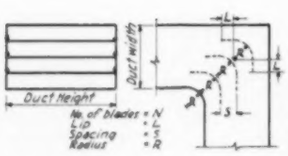
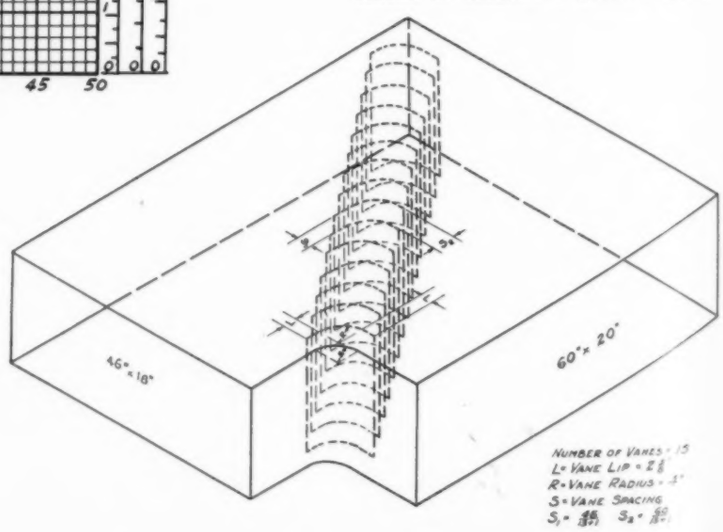


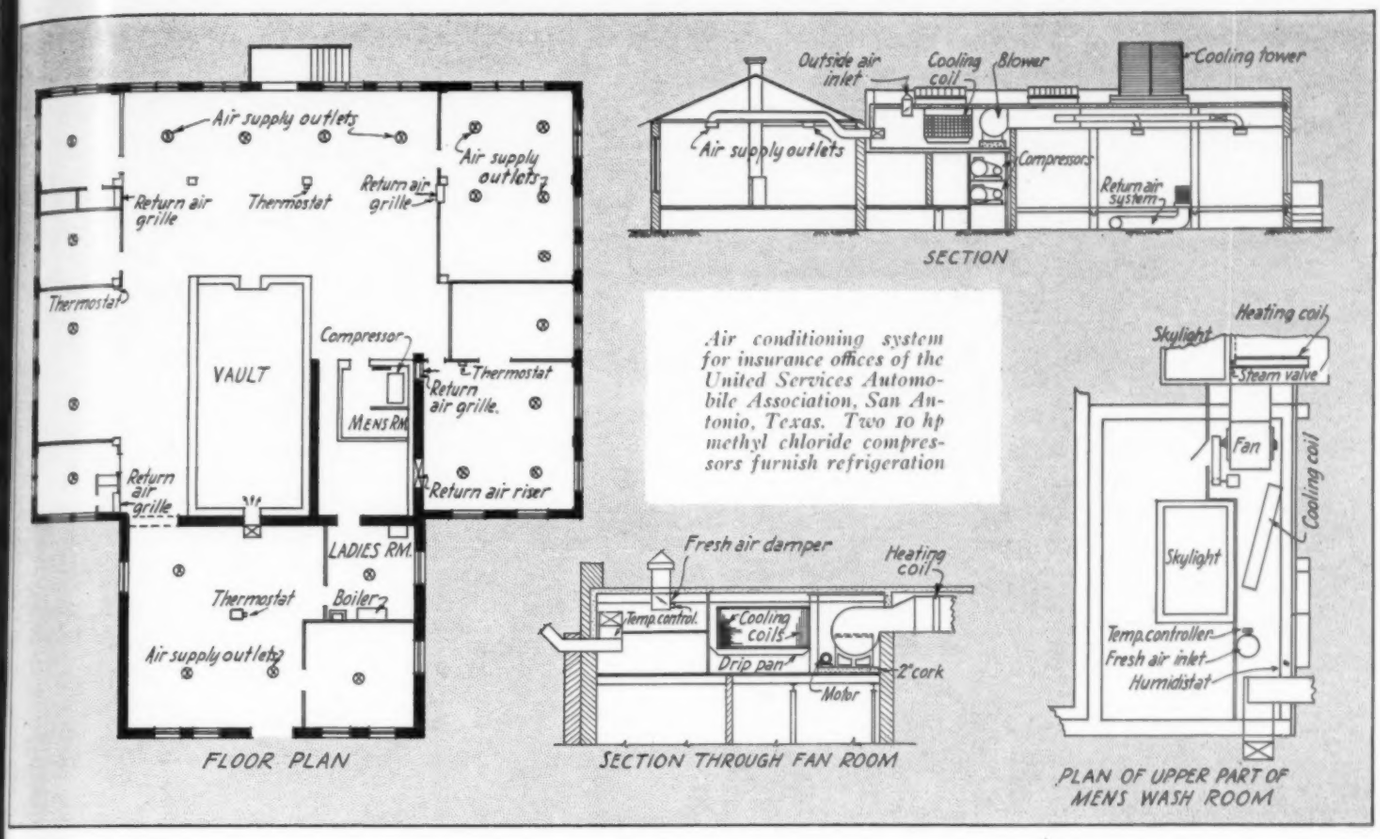
Chart for designing intermediate vanes to be used in duct elbows



Example—Given a duct 20 in. high and 24 in. wide, find number of blades, spacing, radius of blades and lip dimensions. Follow the 24 in. line of the abscissa marked "Duct width" vertically to the first diagonal line after crossing the horizontal or duct height line marked 20 and find "N" or number of blades = 6. Proceed horizontally from diagonal line "N" = 6 to the scales to the right and read the blade radius, "R" = 4⅜ in., the blade extension or lip, "L" = $2\frac{7}{8}$ in. and the blade spacing, "S" = $3\frac{7}{16}$ in.

Sketch of solution of problem given





Savings Pay Operating Cost of Air Conditioning System

By **A. J. Rummel***

RECORDS of twelve months operation of the air conditioning system for the insurance offices of the United Services Automobile Association, San Antonio, Texas, disclose that a reduction of 27 per cent in lost time due to illness was achieved. Absences were reduced from 7.5 to 5.5 days per employee per year; this is attributed to air conditioning. On the basis of the average salary paid the sixty employees the annual saving from reduction of absences was but $28 under the total operating cost of $603 for the year. Since $600 was charged off for interest and depreciation, the saving was about one-half of the owning and operating cost of the air conditioning system.

The building is a one story structure, 90 ft by 100 ft, of stucco, hollow tile, and plaster construction with a flat tar and gravel roof. In the center of the building is a vault, 33 ft by 16 ft wide. The air conditioning system consists essentially of two 10 hp methyl chloride compressors, a 2000 sq ft gas fired steam boiler, cooling and heating coils, fan driven by a 5 hp motor, insulated air distribution ducts, air supply outlets, return grilles, a cooling tower with pump and motor, return ducts under the floor, and a complete temperature control system which maintains a predetermined differential between outside and inside temperatures.

Control of the System

The building is divided into zones, and in each zone is a thermostat which, by means of a motor, opens and closes dampers to control the air supplied to the various zones.

The return air system consists of four return air ducts, one from each zone, which converge at the floor into a riser entering the plenum chamber on the suction side of the fan. In the mouth of the return air riser entering the plenum chamber is a temperature controller which measures the average temperature of the return air from the four zones. In winter this controller actuates a motorized steam valve which supplies steam to the heating coil located on the discharge side of the fan. This valve is provided with an auxiliary switch which operates to

*Air Conditioning Engineer, San Antonio Public Service Co.

Small as well as large offices find that air conditioning pays in promoting employee comfort and reducing absences from work; in the present case, the saving for the first year is computed to be practically equal to the operating cost and about one-half of the total owning and operating cost..... The method of control for both summer and winter operation, which has a number of interesting features, is explained in detail

close the electric circuit to a reverse acting magnetic gas valve on the boiler so that when the steam valve is closed the magnetic gas valve shuts off the gas supply.

The fresh air inlet between the suction side of the fan and the return air inlet to the plenum chamber is controlled by a motor operated single leaf round damper, the operation of which is actuated by means of a second temperature controller in the mixture of the return and fresh air entering the suction side of the fan. After several tests, it was determined that to produce the conditions desired for comfort, the operation of the fresh air damper should be so adjusted that when the mixture of the return and outside air is above 69 F the damper should be in the closed position.

The entire system of control is changed from the winter heating cycle to the summer cooling cycle by means of a series of double pole, double throw switches reversing the low voltage electrical circuits. These switches are mounted on a panel board in the control room and are operated manually. The four thermostats which operate the zone dampers perform the same functions in the summer time as they do in winter except that they are reverse acting.

The temperature controller in the mouth of the return air riser entering the plenum chamber—which measures the average return air temperature from the four zones—operates a multiple step controller. This step controller completes the circuit first to the condenser water pump and second to compressor No. 1, if cooling is required. When the cooling load exceeds the capacity of compressor No. 1, compressor No. 2 starts as a result of continued operation of the step controller on demand of the temperature controller in the return air. In the electric circuit to the condenser water pump and compressors is inserted a control which operates to break the circuit to the compressor on failure of the pump to develop the necessary head pressure to insure water circulation through the condenser coils.

Relative humidity is controlled by means of a humidistat in the plenum chamber which operates to start both compressors simultaneously when the relative humidity in the return air exceeds the design conditions of 50 per cent, regardless of dry bulb conditions. In actual operation it was noted that at no time was the dry bulb temperature lowered more than 2 F below design conditions to satisfy humidity requirements.

The temperature controller actuating the fresh air damper during the summer cooling cycle is so adjusted that when the return air temperature is above 75 F the damper is in the closed position; it is in the open position for return air temperatures of 75 F or less. If and when a temperature of 75 F is reached, the temperature controller which operates the multiple step controller will have operated to shut off the compressors.

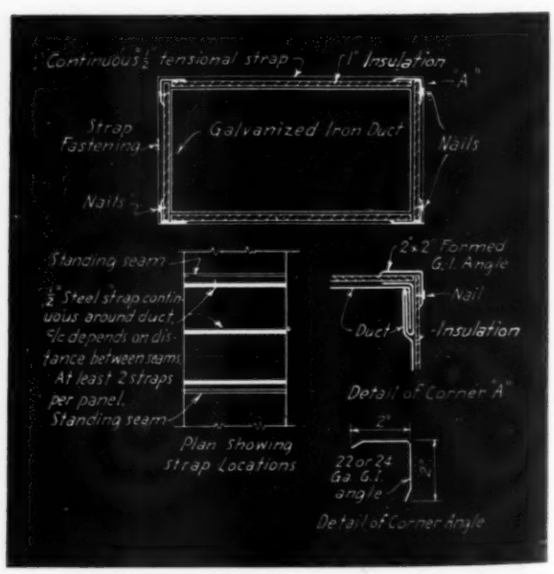
Box Strapping Holds Duct Insulation

An interesting detail of the 40,000 cfm air conditioning system for the home offices of the Upjohn Co., Kalamazoo, Mich., is the use of ordinary steel box strapping for holding the board form duct insulation in place. The method employed speeded up application of the insulation and resulted in a neat appearing and exceedingly tight job.

The insulation was bought in lengths of 8, 10 and 12 ft, in suitable widths. Upon application, it was cut so that each sheet just filled the space between standing seams.

To hold the insulation in place, the top sheet was first laid on the duct. Then the two sides were held in place by the mechanics while a preformed metal angle was laid along the horizontal corner. The top of the angle kept the angle from falling off and nails were driven along the side of the angle to hold up the sheets. With the top and sides in place, the bottom sheet was then held in place while another angle was nailed along the bottom edges of the side sheets.

The ½ in. steel straps were passed around the duct and the fastening machine then pulled the strap tight and clipped the two ends together. Usually one strap was used near each end, but in long sections a third strap was added at the center point.



Detail of method of insulating ducts

Heating·Piping
and Air Conditioning

American Society of Heating and Ventilating Engineers

JOURNAL SECTION

APRIL 1936

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Pyrheliometers and the Measurement of Total Solar Radiation

By **L. A. Harding*** ***(MEMBER)***, **Buffalo, N. Y.**

PHYSICISTS and engineers have for the past 100 years been interested in schemes for the measurement of total solar radiation per unit area received on the earth's surface. Interest in this matter is obviously natural, as life in its various forms existing on this planet is dependent on the cyclic quantity of energy received.

The form of curve obtained on a clear sky day by plotting the intensity of solar radiation with time base is well illustrated on page 277, A.S.H.V.E. TRANSACTIONS for 1932, also page 151, A.S.H.V.E. TRANSACTIONS, 1930.

Various engineers have also, from time to time, interested themselves in experimental plants for the direct or indirect utilization of these rays for water heating and power purposes. Among these may be mentioned the names of Mouchot (1878), W. Adams (1876), M. A. Pifre (1880), John Ericsson (1883), J. Harding (1883), Eneas (1901), Willsie (1904), Shuman-Boys (1913), and recently Georges Claude (1930), whose large scale experiment in Cuba is well known in this country.

Domestic water heating by solar radiation is practiced on a considerable scale in this and other countries and engineers interested in the subject of air conditioning have also quite recently concerned themselves with this matter.

The so-called *sun effect* with comfort cooling installations constitutes, at times, a considerable portion of the heat to be extracted in order to maintain a desired constant temperature condition within the structure. It is now generally recognized as one of the items which must be taken into account by the designing engineer of comfort cooling installations.

The *Smithsonian Institute* maintains a number of stations in various parts of the world where continuous observations of solar radiation are made, while some of the U. S. Weather Bureau stations are now supplied with pyrheliometers and it is assumed that in the future all such stations will be so equipped.

The term *plate*, as hereinafter used, is assumed to be the heat absorbing element exposed to the sun's rays. This element may be a solid of any shape; however, an inverted cone possesses certain advantages as it practically eliminates the question of the efficiency of the absorbing surface as such.

Classification of Instruments

No instrument can provide instantaneous readings of the rate at which total solar radiation is absorbed, on account of the element of time required for obtaining practically thermal equilibrium of the heat absorbing element and also due to the fact that the energy received is constantly varying in amount.

Instruments that have been devised for the measurement of the intensity of solar radiation may be classified, in general, according to the manner in which this measurement is effected. The five ways by which this has been accomplished are:

1. Recording the temperature rise of a liquid or solid substance of known specific heat in a given time.
2. Recording the temperature rise of a given weight of liquid, of known specific heat, in a given time used to remove the heat absorbed by a thin plate or inverted cone.
3. Recording the temperature difference on the two sides of a plate of known conductivity.
4. (*a*) A compensation method using the Joule effect by measuring the heat equivalent of electrical input to a plate, inverted cone or other type of absorber similar in character and dimensions to the heat absorber exposed to the sun's rays. The record is made when these two absorbers are in thermal equilibrium.

   (*b*) A compensation method using the Peltier thermoelectric effect by means of which the heat is absorbed and removed as rapidly as it is received by the heat absorbing element.
5. Recording the temperature of a plate after thermal equilibrium has been established. This instrument must be either calibrated by the use of some other type or the combined surface coefficient for radiation and convection accurately known for the plate with the same range of the temperature difference between the plate and practically still air as may be encountered in practice.

A Frenchman, de Saussre, about 1780, constructed the hot box as indicated by Fig. 1, but it is not known that he made any attempt to estimate the actual amount of solar energy absorbed by the apparatus.

Class 1. The first instrument (Fig. 2) devised for actually estimating the intensity of solar radiation at the earth's surface was invented by the French physicist, Pouillet, 1838. Pouillet gave his instrument the Greek name *pyrheliometer* or "that which measures the fire of the sun." This name has been applied to all subsequent instruments devised for the purpose of measuring total solar radiation.

This type of instrument was somewhat improved by Voille in 1876 (Fig. 3), who placed the bulb of the thermometer at the center of two concentric spheres as shown. Water was circulated between the surfaces of the spheres to maintain a fairly constant temperature for the surface to which radiation from the thermometer bulb takes place.

Instruments in this class are sluggish in action and the correction for heat loss by radiation and convection is generally supposed to be somewhat uncertain. The heat absorbing body in the Voille instrument was the blackened thermometer bulb, the specific heat and weight of which was determined and later used in the calculation. This arrangement, doubtless, permitted obtaining somewhat quicker and more consistent results than with the Pouillet instrument.

Instruments of this type are operated as follows:

(*a*) Observe the fall in temperature (θ_1) for time t when a screen is placed over the instrument.

(*b*) Remove screen and observe the rise in temperature (θ_2) for the same period of time t.

*Pres., L. A. Harding Construction Corp.

For presentation at the Semi-Annual Meeting of the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS, June, 1936, Buck Hill Falls, Pa.

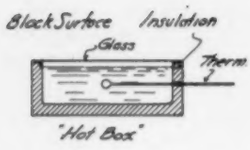

Fig. 1—Hot box of de Saussre—1780

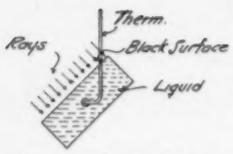

Fig. 2—Pouillet's pyrheliometer—1838

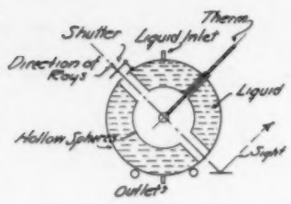

Fig. 3—Voille's pyrheliometer—1876

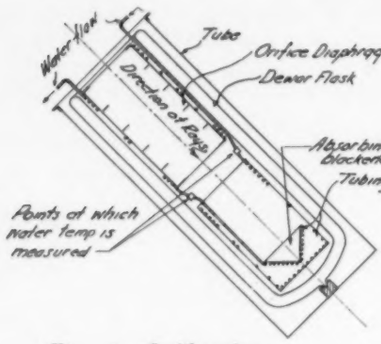

Fig. 4 — Smithsonian Institute standard pyrheliometer

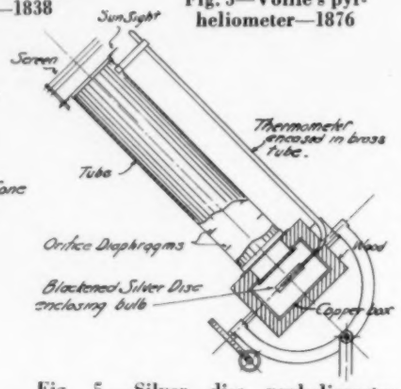

Fig. 5 — Silver disc pyrheliometer (G. C. Abbot)

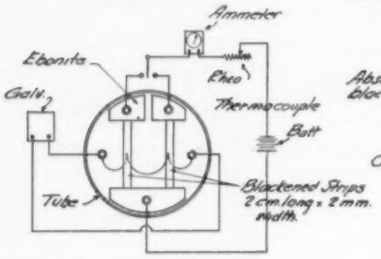

Fig. 6—Compensation type pyrheliometer (K. J. Angström—1893)

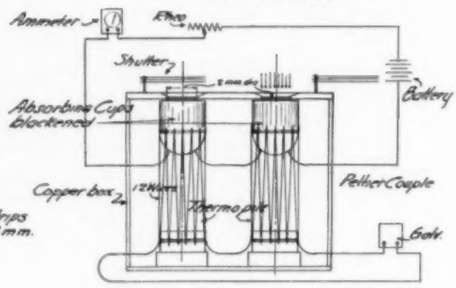

Fig. 7—Compensation type pyrheliometer (H. L. Callender—1910)

(*c*) Replace screen and observe the fall in temperature (θ_3) for time t.

The temperature rise (θ) that would have occurred for time t with no loss by radiation and convection is assumed to be:

$$\theta = \theta_2 - \frac{\theta_1 + \theta_3}{2}$$

The rate of solar energy received is therefore,

$$h = \frac{s w \theta}{A t}$$

in which h = Btu, square feet, hour
s = specific heat, Btu, pounds
w = weight, pounds
A = area surface exposed to normal rays, square feet
t = time exposure, hours

A comparatively recent type of instrument (Fig. 5) based on the same general principle of operation was devised by G. C. Abbot, Secretary of the *Smithsonian Institute*, and is now largely used in this and other countries. The thermometer bulb is embedded in a hollow silver disc with the space between bulb and disc filled with mercury to insure positive contact between the heat absorbing body and thermometer. This instrument is provided with calibration constants which are determined for each individual instrument by comparing readings, taken simultaneously, with the standard Smithsonian water flow pyrheliometer.

Class 2. The water flow pyrheliometer (Fig. 4) was devised by the staff of the *Smithsonian Institute* about 1910 and is considered the standard instrument by which other pyrheliometers in this country are compared and calibrated.

Briefly, the instrument consists of a heat absorbing thin metal blackened inverted cone surface located in a Dewar vacuum flask chamber at the lower end of a tube. The inverted cone is employed to eliminate the uncertainty of the coefficient of absorption which depends not only on the blackness of the surface, but also upon the wave length of the radiation received. The cone provides a black body absorbing surface that is said to give complete absorption with an error of less than 0.1 per cent. A plane surface painted dull black is generally assumed to absorb approximately 98 per cent of the radiation incident upon it.

The purpose of the tube, provided with the orifice plates, is to prevent convection air currents from removing heat from the cone surface. The sun's rays are kept normal to the plane of the cone base.

The underside of the cone and the periphery of the enclosing cylinder for a short distance above the cone is wound with a small diameter tube through which water is circulated. Provision is made for accurately measuring the temperature rise of the water passing through the coil including its rate of flow.

The intensity of solar radiation (h) may then be calculated. w = weight of water passed through apparatus in time t, pounds per hour; s = specific heat water corresponding to the average temperature; θ = temperature rise of the water, degrees Fahrenheit; t = length of exposure, hour; A = area of the aperture directly above cone through which the normal rays pass, square feet; h = intensity of solar radiation received, Btu, square feet per hour, or

$$h = \frac{w s \theta}{A t}$$

Class 3. The only application of the heat transmission principle for the measurement of solar radiation known to the writer was made by F. C. Houghten in 1930 (Fig. 8). He employed a Nicholls heat meter developed by the A.S.H.V.E. Research Laboratory, which is described on pages 139-142, A.S.H.V.E. TRANSACTIONS 1930. The lower side of the meter was placed in direct contact with a water cooled surface and is reported to require approximately 10 min for thermal equilibrium to take place when the intensity of radiation is fairly constant.

It would appear that this class of instrument possesses the virtue of a fair degree of accuracy when the conductivity of the material composing the meter is definitely known for various mean plate temperatures and when the

absorption coefficient for the exposed surface is well established.

Class 4. Compensation types.

(*a*) The first instrument of this class was devised by the Swedish physicist, K. T. Ångström in 1890. (See Fig. 6.) The heat absorbing elements, of similar dimensions (2 cm long × 2 mm wide), were constructed of thin strips of manganin metal. The electrical resistance of this strip of material is practically constant for various temperatures so that only the current, in amperes, need be measured in practice to determine the watts input.

One strip is exposed to the normal rays with the other shielded. An electric current is passed through the latter strip of sufficient strength to just equalize the temperature of the two strips and assuming equal heat loss by radiation and convection from the two strips, it is evident that the heat equivalent of the electrical input (Joule effect) to the first strip must be equal and is the measure of the heat equivalent of the solar energy received by the second strip.

A thermocouple insulated from but attached to the back of each strip, in circuit with a galvanometer, is employed to determine when the temperature is equalized between the strips.

(*b*) The instrument, shown in Fig. 7, was devised by the English physicist, H. L. Callender in 1910.

The radiation received is totally absorbed by a small blackened sheet copper absorbing cup, where it is directly compensated by the absorption of heat due to the well known Peltier effect in a thermojunction formed between the cup and a constantan wire through which a current is passed.

Any change in temperature of the cup is indicated by a galvanometer connected to a thermopile composed of 12 wires (iron and constantan) which support the cup. The cold junctions are attached to the copper casing as indicated. The thermopile is electrically insulated from cup and casing by the use of thin silk paper and paraffin wax. The constancy of the temperature inside the box is indicated by a sensitive thermometer, not shown, placed between the cups. One cup is exposed to the normal rays and a measured current allowed to flow through the thermojunction of the couple attached to the cup.

The value of the Peltier coefficient P for a single copper-constantan junction is approximately 12 millivolts, which when multiplied by the current C in amperes gives the heat absorption PC in milliwatts.

With an aperture of 2 mm diameter, the current required to compensate for mean solar radiation (0.070 watt per square centimeter or 222 Btu, square feet) is about 200 milliamps with a single thermocouple. In practice the current is passed through the Peltier junction of both cups so that the exposed cup is cooled while the screened cup is heated. This doubles the effect and requires a current of 100 milliamps. The equation for the intensity (h) of solar radiation received and measured in milliwatts per square centimenter is:

$$h = 2PC/a \qquad a = \text{area of aperture, square centimeters}$$

The value of P may be accurately determined by fitting a resistance coil in the cup and measuring the heating effect.

The author, adopting the principle used by Ångström, constructed the pyrheliometer in 1934 shown by Fig. 10. This instrument consists of two similar 45 deg inverted cones constructed with 0.035 in. thickness brass sheet. Each inverted cone is 4.2 in. diameter with a face area of 0.0962 sq ft. The cones are supported by thin cardboard attached to the brass plate as indicated and the plate movement is controlled by a worm and worm gear.

One cone is wound on the inside with No. 34 gage silk insulated wire, approximately ⅛ in. pitch winding and the winding is covered with thin paper shellacked in place.

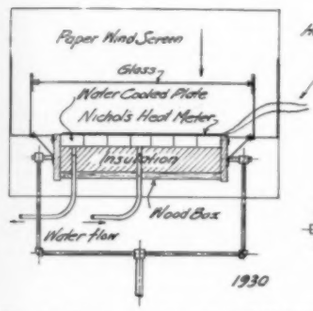

Fig. 8—Cross section of A.S.H.V.E. Research Laboratory pyrheliometer —1930

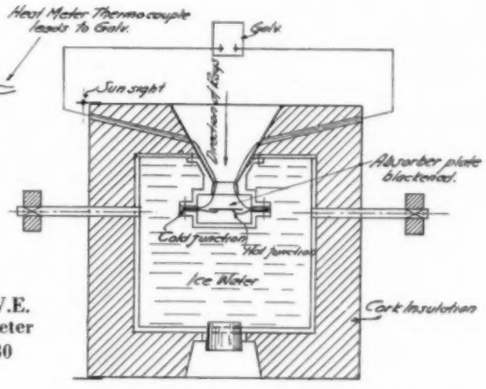

Fig. 9—Cross section of A.S.H.V.E. Research Laboratory pyrheliometer—1932

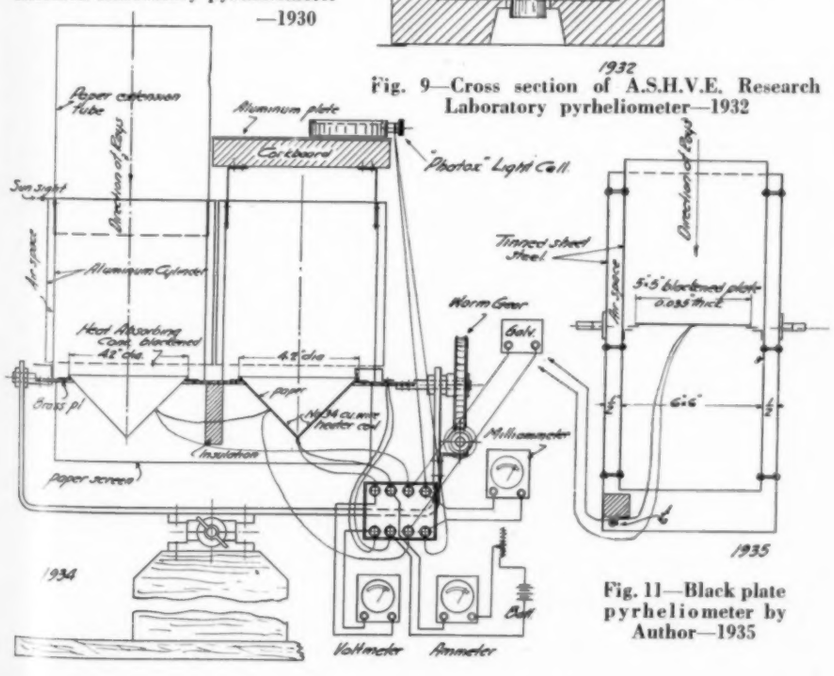

Fig. 10—Compensation type pyrheliometer by Author—1934

Fig. 11—Black plate pyrheliometer by Author—1935

The cone surfaces are painted dull black inside and out with lampblack, shellac and alcohol.

The direct current for operation is supplied from two 6-volt automobile batteries, controlled by a rather finely wound rheostat. Current measurements are taken by means of a voltmeter and ammeter.

The heater element is screened from the sun's rays by means of a cork shield, as indicated, covered on top with sheet aluminum. A copper-constantan couple is soldered to each cone in circuit with a galvanometer; the galvanometer reading being zero, when the two cones are in thermal equilibrium.

A reading is obtained by first pointing the instrument toward the sun by means of the sight, then adjusting the current by means of the rheostat until the two cones are the same temperature. The current input, in watts, is recorded and the rate at which solar heat is received is then determined by the equation,

$$h = \frac{\text{watts} \times 3.415}{0.0962} = 35.4 \text{ watts, Btu, square feet, hour}$$

This instrument has been used at various times during the past two years with good success. It was recently used to determine the solar heat transmitted by a special type of heat absorbing glass, as referred to later in this paper. The size of this instrument was determined largely by the fact that it was desired to use standard types of voltmeters and ammeters provided with tenth scale divisions. The larger the heat absorbing element in this type of instrument, the less is the likelihood of errors in the final results obtained. The obvious objection to this instrument is the fact that the set-up is somewhat complicated by the amount of apparatus involved.

The calibration of the heater cone shown by Fig. 12 for 70 deg air is used as a general guide in checking field measurements. The relation between the volt-ampere readings is affected by the air temperature, as would be expected, due to the increase in resistance of the copper wire winding as the air temperature increases. This complication could be removed by employing manganin wire for the heater cone, in which case it would only be necessary to read one current measuring instrument (ammeter) as the resistance of the manganin wire is little affected by its temperature.

Class 5. An instrument of this type (Fig. 9) was devised by F. C. Houghten and associates in 1931 and used by the A.S.H.V.E. Research Laboratory staff for solar radiation determinations. This instrument, which is fully described in A.S.H.V.E. TRANSACTIONS for 1932, was calibrated by means of the Abbot pyrheliometer.

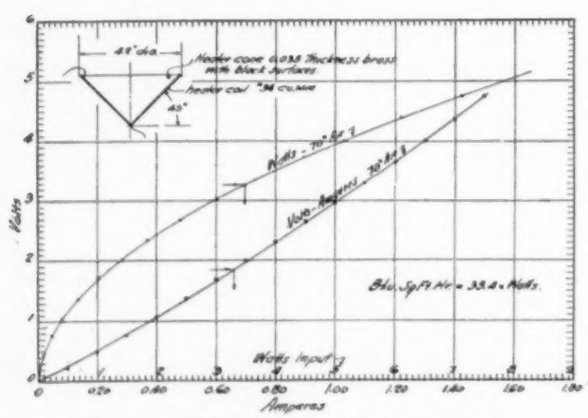

Fig. 12—Calibration curves for heater cone

The small heat absorbing plate is provided with two thermocouples, the cold junctions of which are located outside of the space surrounding the plate.

A reading of the galvanometer indicates the temperature differences between the heat absorbing plates and its surrounding enclosed space maintained constant with ice water.

This instrument possesses the advantage of a quick reading and consequent determination of the solar energy being received.

Description of Black Plate Instrument

The black plate pyrheliometer shown by Fig. 11 was constructed by the author in 1935 in an attempt to devise a simple type of apparatus which may be readily constructed and operated. It has been used to a limited extent with apparently satisfactory results.

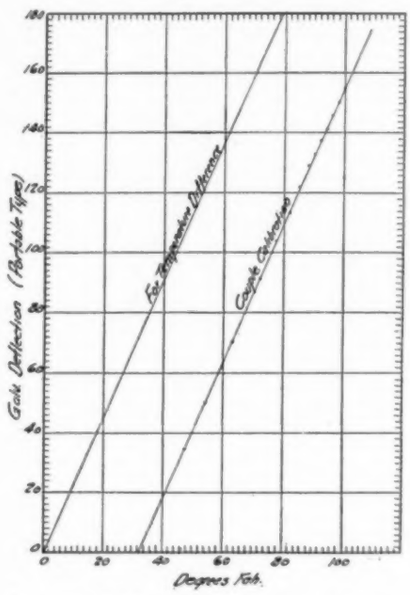

Fig. 13—Calibration of heater and sun plate thermocouple

The heat absorbing plate consists of a 5 in. by 5 in. brass plate 0.035 in. in thickness blackened both sides. The plate is supported in a housing as indicated and the inner surface of the inside enclosure is painted black. The two concentric enclosures are constructed of bright tinned sheets.

A copper-constantan thermocouple is soldered to the plate, the cold junction being soldered to a thin sheet brass strip enclosing the thermometer bulb, screened from the plate and sun's rays as indicated.

A portable type galvanometer, provided with a scale, is used to indicate the temperature difference between the plate and the air.

It is obvious that the heat absorbing element must be protected against air currents and the combined coefficient of radiation and convection (k) be carefully determined in comparatively still air. Four different electrically heated plates were constructed each 5 in. by 5 in.

but of various materials, thicknesses and copper wire resistance windings. The outside surfaces of the plates were painted dull black with lampblack mixed with shellac and alcohol.

The watts input to the heater were determined in the customary manner and the value of k determined with the heater plate in the position to be occupied by the heat

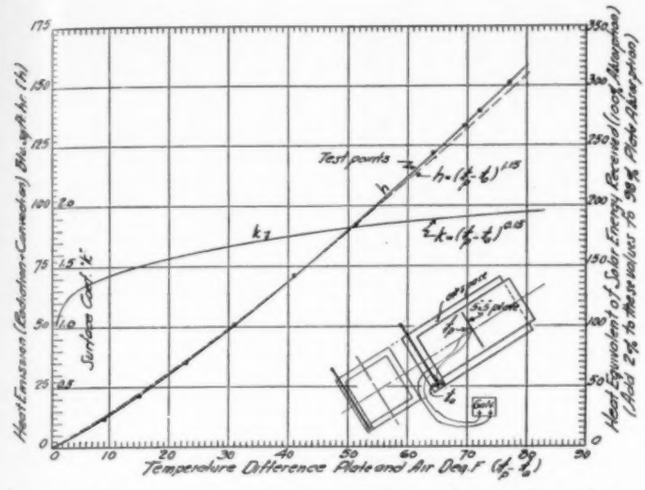

Fig. 14—Calibration curves for 5 in. x 5 in. black surface plate in enclosure

absorbing plate in the open end enclosure. The results of several hundred observations obtained with the various plates checked quite closely.

Heater Plate Results

The results were plotted with divisions for the ordinates of 1 Btu, square foot, hour and ½ F temperature difference for the abscissa.

Fig. 14 gives the results of the heater plate tests. The two curves for k and h indicate the variation obtained for various temperature differences between the plate and air. The heat emitted per square foot per hour (test results) for various temperature differences is given by the equation,

$$h = (t_p - t_a)^{1.15}$$

and the heat emitted per square foot per hour per degree difference by the equation,

$$k = (t_p - t_a)^{0.15}$$

in which t_a = temperature air and t_p = temperature plate degrees Fahrenheit.

The writer is of the opinion that the calibrated blackened thin plate type pyrheliometer, as described, is sufficiently accurate for practical use.

The only instrument required is a portable type galvanometer provided with scale and a suitable shunt. The accuracy of the combination depends largely upon the accuracy of the original calibration, prevention of strong currents of air from entering the open ended enclosure and an allowance (98 per cent) for reflected rays. The latter allowance may be eliminated, if a calibrated cone were employed in place of the flat type plate absorber.

The calibration of the plate should be made in the same position as that in which it is to be used. The plate calibration, by the author, was made with the enclosure placed at an angle of 40 deg with the horizontal. There appears to be little or no difference in calibration between a 40 deg and a 15 deg angle.

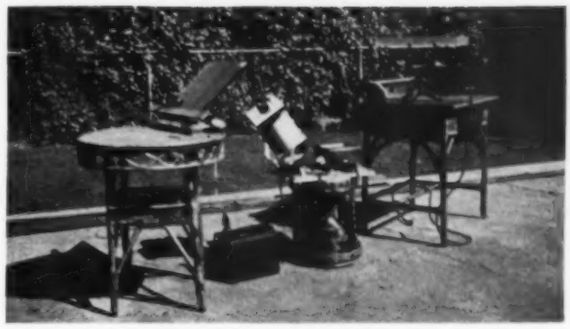

Fig. 15—Arrangement of compensation type pyrheliometer used for heat absorbing glass tests

Incidentally, this appears to be the general form of equation for the heat transfer from pipes to still air. The author recently tested a blackened ¼ in. brass pipe 3 ft. 0 in. long, suspended in still air, electrically heated, with the result.

$$h = (t_p - t_a)^{1.20} \text{ and } k = (t_p - t_a)^{0.20}$$

The author is not in a position to vouch for the preceding equations beyond the temperature differences and a comparatively low range of temperatures used in these tests.

A fairly close check (averaging 1 per cent) was obtained in the laboratory between instruments as shown by Figs. 10 and 11 using the heat and light emitted by a 250 watt lamp. No direct comparative field tests have been made between the two instruments.

Measurement of Solar Radiation Through Glass

These instruments were used during the past summer in Buffalo, N. Y., to determine the transmission of solar radiation through a pane of heat absorbing glass, manufactured in England and having a thickness of ⅜ in.

The averages of a considerable number of tests obtained with this glass were as follows. The percentages refer to 100 per cent solar energy received with rays normal to the glass and the heat absorbing elements.

Heat absorbed and reflected	77 per cent
Heat transmitted	23 per cent

When glass is used in building construction, approximately one-half of the heat absorbed by the glass may be assumed to also enter the interior of the building by radiation and convection from the hot glass surface. The estimated heat gain for the heat absorbing glass on the basis of this assumption would be: 38.5 + 23 or 61.5 per cent. Actually the percentage would probably be somewhat less due to the higher temperatures of the outside surface of the glass.

The same kind and thickness of glass was tested, in Pittsburgh, Pa., by F. C. Houghten at about noon October 31, 1935. Two readings, taken approximately 20 min apart, resulted in the same percentages previously reported. The maximum heat received was 245 Btu per square foot per hour. The pyrheliometer used by Mr. Houghten in this test is shown by Fig. 9.

The following is a typical set of readings taken by the author with the black plate pyrheliometer (Fig. 11) and recorded in Buffalo, N. Y., on November 24, 1935. The readings shown were taken at 12:15 and 12:20 p. m., Eastern Standard Time.

Angle of rays with horizontal, approximately 31 deg. Air temperature 37 F

	No Glass	Heat Absorbing Glass
Galvanometer deflection	139	39
Temperature difference plate and air degrees Fahrenheit ($t_p - t_a$)	61	17.2
Btu, square feet, hour received (assumed 98 per cent plate absorption)	234.6	55
Per cent heat transmitted	...	23.4 per cent
Per cent heat absorbed and reflected	...	76.6 per cent
Photox cell—milliamps	8.8	5.2
Per cent light transmitted	...	60.0 per cent

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Conference on Air Conditioning to be Held

Announcement has been made of a two-day Conference on Air Conditioning sponsored by the Department of Mechanical Engineering, College of Engineering, University of Illinois, to be held May 4 and 5 at Urbana, Ill.

The purpose of the conference is to present practical information on air conditioning to the non-technically trained citizen. The following phases of the subject will be included: clarification of the term *air conditioning,* simple calculations required, explanations of the functions and limitations of available equipment, and the results of research relating to health and comfort.

There will be no charge for registration or attendance and the cost of the dinner planned for the evening meeting on May 4 will be nominal. All daylight sessions, on Central Standard Time, will be held in Room 215 of the Electrical Engineering Building, and the laboratories of the Department of Mechanical Engineering and the Warm Air Research Residence will be open to visitors.

The program, which is planned, is included and complete information may be obtained from Prof. P. E. Mohn, chairman of the Committee on Arrangements, 1936 Conference on Air Conditioning, University of Illinois, Urbana, Ill.

Monday, May 4
(Morning Session)
Dean M. L. Enger, Presiding

9:30—Greeting—M. L. Enger, Dean of the College of Engineering, Director of Engineering Experiment Station, University of Illinois.

What Is Air Conditioning—A. C. Willard, President of the University of Illinois.

Comfort Conditions and Physiological Factors—F. C. Houghten, Director of Research Laboratory, American Society of Heating and Ventilating Engineers, Pittsburgh, Pa.

Physical Factors Affecting Comfort—A. P. Kratz, Research Professor of Mechanical Engineering, University of Illinois.

(Afternoon Session)
O. A. Leutwiler, Presiding

1:30—Essential Features of Heating Systems, P. E. Mohn, Assistant Professor of Mechanical Engineering, University of Illinois.

Factors Affecting Fuel Saving, S. Konzo, Special Research Associate in Mechanical Engineering, University of Illinois.

Inspection of Air Conditioning Test Plants—In the Mechanical Engineering Laboratory and the Research Residence.

Monday, May 4
(Evening Session)

6:30—Dinner—President Willard, Presiding.

Air Conditioning and Its Effect on Hay Fever and Asthma, Dr. W. H. Welker, Professor of Physiological Chemistry and Head of Department, College of Medicine, University of Illinois, Chicago.

Tuesday, May 5
(Morning Session)
A. P. Kratz, Presiding

9:00—Estimating the Humidification Requirements of Residences, W. H. Severns, Professor of Mechanical Engineering, University of Illinois.

Air Filters in Air Conditioning Systems, F. B. Rowley, Professor of Mechanical Engineering, University of Minnesota, Minneapolis, Minn.

Air Conditioning Equipment, E. L. Broderick, Research Assistant in Mechanical Engineering, University of Illinois.

(Afternoon Session)
W. H. Severns, Presiding

1:30—Estimation of Comfort Cooling Requirements, H. J. Macintire, Professor of Refrigeration, University of Illinois.

Research in Summer Cooling at the University of Illinois, M. K. Fahnestock, Research Assistant Professor of Mechanical Engineering, University of Illinois.

Inspection of Air Conditioning Test Plants—In the Mechanical Engineering Laboratory and the Research Residence.

Room Surface Temperature of Glass in Windows

By **J. E. Emswiler*, Ann Arbor, Mich., and W. C. Randall**, Detroit, Mich.** ***(MEMBERS)***

The results presented in this paper were obtained in connection with a project sponsored by the Technical Committee of the Metal Window Institute and conducted at the University of Michigan in the Department of Engineering Research. Special acknowledgment is due the following members of the Institute: Detroit Steel Products Co., Truscon Steel Co., William Bayley Co., Hope's Windows, Inc., Concrete Engineering Co., Crittal Manufacturing Co., and Mesker Brothers' Iron Co., who contributed to this research program.

THE room surface temperature of glass in windows is determined by a percentage of the total difference in temperature between inside and outside air. Actual test results, almost without exception, indicate that this percentage is a constant factor for any particular kind of window and wind condition, and for all temperatures of outside air. The use of factors representing the various percentages or ratios will allow the solution of problems concerning the depositions of moisture on single, double glazed windows or double windows, as well as other problems involved in the use of windows for the modern air-conditioned installations.

The increasing use of air-conditioning with relatively high humidities has made imperative the solution of the problem of the factors involved in the deposition of moisture on the room surface of glass in windows. Engineers and manufacturers of windows are frequently requested to make recommendations regarding the elimination or control of this excessive deposition.

Experimental Determination of Factors for Room Surface Temperatures

The apparatus for the tests consisted of a *cold box,* in which low temperatures could be produced by dry ice (solid carbon dioxide) placed in bunkers; and a *warm box,* in which room temperature could be maintained by electric heaters. An opening was provided for a window with dimensions of approximately 40 in. wide by 54 in. high and was located in the wall separating the warm and cold boxes. Temperatures were obtained by thermocouples, as explained in the following description of the apparatus.

Humidity of the air in the warm box was measured by wet and dry bulb thermometers. Determining dew point temperature from air temperature and humidity, and observing when moisture first appeared on a window under test, gave an independent check of observations from thermocouples on the windows. A similar check was obtained when frost first appeared.

Moisture was deposited upon the window surfaces in many of the single window tests, and ice was often present with low cold box temperatures. Their presence on the window seemed to produce little or no effect upon temperature relations, in other words, the temperature drop did not seem to be affected by moisture or frost.

Each window was tested at three different cold (outside) air temperatures, about 35 F, 15 F, and —5 F in the cold box with and without wind, and with warm air temperature in the warm box kept at room temperature.

Apparatus and Method of Testing

The test apparatus consisted of a *cold box* to simulate outside conditions and a *warm box* to simulate room conditions, with the window under test mounted in a frame between them, and the necessary thermocouples and thermometers to measure the desired temperatures.

Fig. 1—Window side of cold box showing location of thermocouples

*Professor of Mechanical Engineering, University of Michigan.
**Chief Engineer, Detroit Steel Products Co.; *Chairman,* Technical Committee, *Metal Window Institute.*

Presented at the 42nd Annual Meeting of the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS, Chicago, Ill., January, 1936.

Fig. 2—View of warm box showing thermocouples and humidity recorder

The cold box was 8 ft 6 in. high by 5 ft square, built of 1 in. matched lumber on 2 in. x 4 in. framing, and covered with 1½ in. of insulating board. The window under test was installed in a 54½ in. x 40 in. opening in the front of the box. Cooling was accomplished by the use of carbon dioxide ice placed in galvanized sheet metal bunkers inside the box at the top and back. The carbon dioxide gas evolved was piped off to a manifold on the side of the box and discharged out-of-doors. Cold box temperatures were controlled by addition or removal of ice from the bunkers.

Wind on the outside surface of the window was produced by a motor driven blower inside the cold box, with the outlet connected to two vertical headers having holes drilled in them to direct the streams of air toward the window surface at an angle of approximately 45 deg. Iron constantan thermocouples guarded against radiation were located at four levels on the cold side of the window, spaced 6 in. from the glass surface, as shown in Fig. 1. All thermocouples were made of No. 28 wire.

White curtains were hung in the cold box to prevent direct radiation to the extremely cold bunker surfaces. A gasket of rubber tubing fastened to the frame around the window opening sealed the joint where the two boxes were clamped together.

The warm box was 89 in. high, 44 in. wide, and 32 in. deep, built of ⅜ in. plywood on 2 in. x 2 in. framing, covered with ½ in. of insulating board. A 54½ in. by 40 in. opening in the front fit the window opening in the cold box. A 2 ft square observation window was mounted in back of the box.

Heat was supplied by electric strip heaters in the bottom of the box, guarded against direct radiation to the windows and box walls. A variable resistance outside the box was used to control the electrical input to maintain constant temperatures in the warm box.

Relative humidity was determined from readings of wet and dry bulb thermometers on a shelf in the warm box visible through the observation window. A small blower was used to circulate air across the thermometer bulbs.

Thermocouples were located 6 in. from the room surface of the glass at four zones opposite the cold box thermocouples as shown in Fig. 2. Glass temperatures were obtained from thermocouples flattened and secured to the glass surface with thin cement.

A compensated potentiometer indicator was used with a calibration chart to obtain the temperatures at the various thermocouple locations. Double pole knife switches as shown in Fig. 3 were used to select the desired thermocouples for temperature measurements.

Fig. 3—Warm box and cold box placed together for test

Test runs were of two to three hours duration at constant temperature conditions with readings recorded every 15 min. Two and a half to three hours time was allowed before each test to reach stable conditions.

The Factor R for Room Surface Temperature of Glass in Windows

The values of this factor or ratio R were obtained by substituting test results in the following formula:

$$R = \frac{t_r - t_g}{t_r - t_o} = \frac{\text{room temperature—temperature room side of glass}}{\text{room temperature—temperature of outside air}} \quad (1)$$

Sketches A and B of Fig. 4 indicate the approximate places at which thermocouples were placed on the glass.

Table 1—Temperature Results of Single Double Hung Wood and Light Steel Casement Windows

Windows	Single Double Hung Wood			Single Light Steel Casement		
Test No.	42	43	44	57	58	59
Air Temperature (Aver.)						
t_r	75.9	74.3	71.7	73.9	73.9	71.4
t_o	36.4	17.3	− 2.3	36.9	18.6	− 0.5
Glass Temperature (Aver.)						
t_2	—	—	—	49.5	38.1	24.2
t_3	—	—	—	47.8	34.6	20.3
t_4	51.8	39.2	26.8	49.2	36.5	22.8
t_5	49.8	36.4	23.9	49.6	36.4	23.8
t_6	—	—	—	50.7	37.2	24.9
t_7	47.0	32.3	17.9	—	—	—
Temperature Drops						
$t_r - t_o$	39.5	57.0	74.0	37.0	55.3	71.9
$t_r - t_2$	—	—	—	24.4	35.8	47.2
$t_r - t_3$	—	—	—	26.1	39.3	51.1
$t_r - t_4$	24.1	35.1	44.9	24.7	37.4	48.6
$t_r - t_5$	26.1	37.9	47.8	24.3	37.5	47.6
$t_r - t_6$	—	—	—	23.2	36.7	46.5
$t_r - t_7$	28.9	42.0	53.8	—	—	—
Ratio of Temperature Drops (Factor R in percent)						
$(t_r - t_2) \div (t_r - t_o)$	—	—	—	66	65	66
$(t_r - t_3) \div (t_r - t_o)$	—	—	—	71	71	71
$(t_r - t_4) \div (t_r - t_o)$	61.0	61.5	61.0	67	68	67
$(t_r - t_5) \div (t_r - t_o)$	66.0	66.5	65.0	65	68	66
$(t_r - t_6) \div (t_r - t_o)$	—	—	—	63	66	65
$(t_r - t_7) \div (t_r - t_o)$	73.0	74.0	73.0	—	—	—
Average Factor R	66.8			67.0		

Typical examples of test observations and results from two of the windows are shown in Table 1.

Value of R as Determined from Tests

The charts of Fig. 5 (with wind) and Fig. 6 (without wind), present the values of R, as found from the tests, in a graphical form. In explanation, the scale at the top of the charts, extending from 0 to 100, may be considered as *per cent*. The total length of each bar is 100, and represents the total temperature difference $(t_r - t_o)$ between inside and outside temperature through a window, from warm to cold air. The length of the cross-hatched portion of each bar represents the drop in temperature from warm air to room surface of glass $(t_r - t_g)$. Since the total length of a bar is 100 per cent, the length of the cross-hatched part also represents the value of R, that is

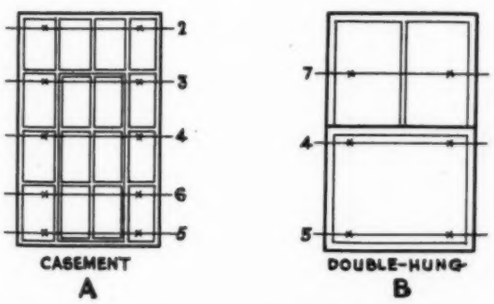

Fig 4—Sketches showing location of thermocouples on glass surface on room side of window

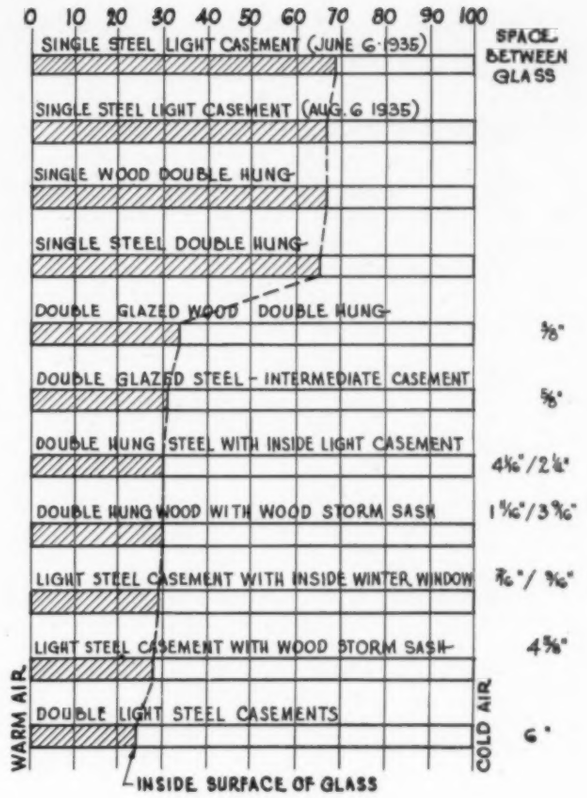
0 10 20 30 40 50 60 70 80 90 100
SINGLE STEEL LIGHT CASEMENT (JUNE 6 1935)
SINGLE STEEL LIGHT CASEMENT (AUG. 6 1935)
SINGLE WOOD DOUBLE HUNG
SINGLE STEEL DOUBLE HUNG
DOUBLE GLAZED WOOD DOUBLE HUNG
DOUBLE GLAZED STEEL - INTERMEDIATE CASEMENT
DOUBLE HUNG STEEL WITH INSIDE LIGHT CASEMENT
DOUBLE HUNG WOOD WITH WOOD STORM SASH
LIGHT STEEL CASEMENT WITH INSIDE WINTER WINDOW
LIGHT STEEL CASEMENT WITH WOOD STORM SASH
DOUBLE LIGHT STEEL CASEMENTS
SPACE BETWEEN GLASS
⅜"
⅝"
4⅛"/2⅛"
1 ¾"/3 ⅜"
⅞"/ ⅜"
4⅝"
6"
WARM AIR
COLD AIR
INSIDE SURFACE OF GLASS

Fig. 5—Values of R with wind

$$R = \frac{t_r - t_g}{t_r - t_o} = \frac{\text{Room Temperature—Temperature Room Side of Glass}}{\text{Room Temperature—Temperature of Outside Air}}$$

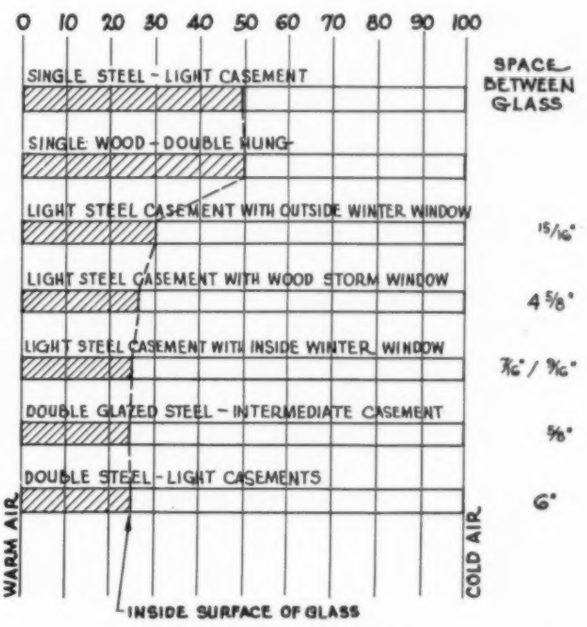
0 10 20 30 40 50 60 70 80 90 100
SINGLE STEEL - LIGHT CASEMENT
SINGLE WOOD - DOUBLE HUNG
LIGHT STEEL CASEMENT WITH OUTSIDE WINTER WINDOW
LIGHT STEEL CASEMENT WITH WOOD STORM WINDOW
LIGHT STEEL CASEMENT WITH INSIDE WINTER WINDOW
DOUBLE GLAZED STEEL - INTERMEDIATE CASEMENT
DOUBLE STEEL - LIGHT CASEMENTS
SPACE BETWEEN GLASS
15/16"
4 5/8"
⅞"/ ⅜"
⅝"
6"
WARM AIR
COLD AIR
INSIDE SURFACE OF GLASS

Fig. 6—Values of R without wind

$$R = \frac{t_r - t_g}{t_r - t_o} = \frac{\text{Room Temperature—Temperature Room Side of Glass}}{\text{Room Temperature—Temperature of Outside Air}}$$

the ratio $\dfrac{t_r - t_g}{t_r - t_o}$ in per cent, for that particular window.

Inspection of the charts of Figs. 5 and 6 shows that the values of R fall into two rather well-defined groups, that

is single windows and double windows, the latter including double glazed windows, all of which are summarized in Table 2.

Typical Examples of the Use of Factor R

Formula 1 shows how the factor R is derived from test data (as illustrated in Table 2) for different types of windows. The equation or the formulae may be rewritten for convenient use in solving a particular unknown value in a definite problem. For example, to determine outside temperature,

$$t_o = t_r - \frac{t_r - t_g}{R} \qquad (2)$$

The use of the factors will be illustrated by the following examples:

(a) At what outside temperature, with wind, will moisture begin to appear on the glass of a single window when the inside temperature is 70 F, and the relative humidity is 30 per cent?

From Fig. 5 (or Table 2) it is found that, for single windows, with wind, R is about 67 per cent. From a psychrometric chart, or by the use of steam tables, the dew point for 70 F and 30 per cent relative humidity is found to be 37 F, which would be the glass temperature at which moisture would begin to appear. Substituting these known values in equation (2) we find t_o, or outside air temperature to be approximately 21 F.

(b) At what outside temperature will frost appear on the window of example (a) for the condition stated?

Condensation forming at a glass temperature of 37 F will be in the form of moisture. However, if the glass temperature is 32 F, or less, this will be in the form of frost. Using 32 F as t_g in formula (2) we find the outside temperature to be about 13 F.

(c) With a double steel window and with inside temperature 70 F and a relative humidity of 45 percent, how low may the outside temperature go before moisture will appear on the glass, with wind?

The chart of Fig. 5 gives R for this window to be about 25 per cent and the dew point for the stated conditions is found from a psychrometric chart to be 47.5 F. These known values substituted in equation 2 gives an outside temperature of —20 F. If the average factor of 30 per cent for double windows is used as given in Table 2, we get an outside temperature of —5 F.

These examples indicate the practical application of the information derived from these experiments. It is possible to tabulate the results for problems of a similar nature, as shown in Table 3.

The conclusions that may be drawn from such a tabulation would be:

(1) For single windows and 30 per cent relative humidity, there will be deposition on the glass with an outside temperature of about 22 F. For a change in relative humidity of 1 per cent, the outside temperature at which moisture will form changes about 1 F.

(2) For double windows the relative humidity apparently must be more than 45 per cent to cause deposition when the outside temperature is 0 F. An increase in the relative humidity increases the outside temperature at which moisture will form by about 2 F for each 1 per cent increase in relative humidity.

(3) A further examination of Figs. 5 and 6 showing actual test results indicates that there is practically no difference in the room surface temperature of single glass in steel and in wood windows. There appears to be some difference in the cases of double glass although this may be accounted for by the difference in the air space between the panes of glass.

(4) A high degree of precision was not sought in these tests. Greater accuracy might have been attained by tests of longer duration, and with perhaps longer transition periods between tests. It is confidently believed, however, that the results obtained are well within the degree of precision warranted by the application of the data; and by dispensing with extreme refinement in the testing, it was possible to cover a much wider range of window types than could otherwise have been done with the time and funds available.

Table 2—Values of R for Glass for General Window Types

General Type of Window	Wind Condition	R for Glass in Per Cent (Approx.)
Single Windows	With wind	67
Double Windows	With wind	30
Single Windows	Still air	50
Double Windows	Still air	25

Table 3—Outside Temperature at which Deposition will Occur for 70 F Inside Temperature, with Wind

Relative Humidity in Per Cent	F for Dew Point or t_g	F for Single Windows R=0.67	F for Double Windows R=0.30
25	32.5	14.0	−55.0
30	37.5	21.5	−38.5
35	41.0	27.0	−26.5
40	44.5	32.0	−15.0
45	47.5	36.5	− 5.0
50	50.5	41.0	+ 5.0
55	53.5	45.5	+15.0

Check with Guide Data

The value of the ratio R depends upon the ratio of surface coefficient for the glass. Let c = the ratio of the surface coefficient for wind (f_o) to that for still air (f_1). Then $c = f_o/f_1$. From equation in The A.S.H.V.E. Guide 1935, page 93, and statements on pages 116 and 118, it can be shown that $R = \frac{c}{c+1}$ for single glass and $R = \frac{c}{3c+1}$ for double glass, when the resistance of the glass itself to heat transfer is considered to be zero.

Using the values $f_1 = 1.50$, and $f_o = 4.50$, given in The Guide previous to 1933, $c = f_o/f_1 = 3$ and R, for single glass, $= 0.75$, and for double glass 0.30. It can also be readily shown that the overall coefficient of transmission, U, is equal to $R \times f_1$, hence, for single windows, $U = 0.75 \times 1.50 = 1.125$ or 1.13, and for double windows, $U = 0.30 \times 1.50 = 0.45$, which are the values given in The Guide 1935, page 113.

Later values of $f_1 = 1.65$ and $f_o = 6.00$ are given in The Guide 1935, page 98, and using these, R for single glass, is 0.78 and for double glass, 0.305. When the overall coefficient is computed, using $f_1 = 1.65$ and $f_o = 6.00$, it is found that $U = 1.29$ for single glass, and $U = 0.50$ for double. Thus there is a discrepancy between the values of U and those of surface coefficient as given in The Guide.

The value of $R = 0.67$ for single glass, based on test

results as given in this paper, is less than $R = 0.75$ and 0.78 resulting from calculations based on surface coefficient values given in THE GUIDE. Possibly the wind effect upon the outside glass surface in these tests was less than that previously determined as produced by a 15 mph wind, which accounts for the smaller value of R. For double glass, the whole effect of the wind is minimized to the point where the test results and calculated values are closer.

The larger the value of R used, the higher will be the calculated temperature of outside air to cause deposition of moisture. Thus in Table 2, if R is taken at 0.75 instead of 0.67, the outside temperature to cause deposition on single windows, with 25 per cent relative humidity is 20 F; with 45 per cent, 40 F; and with 55 per cent, 48 F.

If the test value of R is correct, then the surface coefficients as now shown are incorrect. A revised value of U could be determined based on revised values for surface coefficients if discrepancies of the magnitude indicated from these tests would warrant such a revision.

A point of interest is that the value of R of 0.67 for wind is reduced to 0.50 for no wind and for double glass from 0.30 to 0.25. This would seem to indicate that the actual heat loss would be reduced 25 per cent for single windows and 15 per cent for double windows for those not exposed to the wind.

Acknowledgment

The authors wish to acknowledge the work of L. V. Beukema, who conducted the laboratory work, also the cooperation of R. C. Montgomery, R. L. Carlson, R. L. Clingerman, E. W. Conover, and R. H. Sartor.

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Tests of a Gas-Vapor Heating System

By **R. R. Seeber,* *(MEMBER)* G. E. Smedberg† and A. E. Felt† *(NON-MEMBERS)***
Houghton, Mich.

DURING the summer of 1935 three tests of a gas-vapor heating system were made in the research laboratory of the Michigan College of Mining and Technology at Houghton, Mich.[1] These tests included the securing of information on the construction and operation of the equipment and on the heat efficiency obtained under varying conditions. A detailed study was made of the durability of the various parts of the system. In it a piping arrangement was used which was similar to that used in studying corrosion in iron pipe return mains, results of which were given in previous papers[2] presented to the Society.

In the gas-vapor system all pipes are copper tubes. Fittings are made of brass, and the generator is made of a non-rust copper alloy. The system is unique in that the products of combustion are mixed with the steam in a generator and used to convey heat to the more remote radiators under pressures below that of the atmosphere.

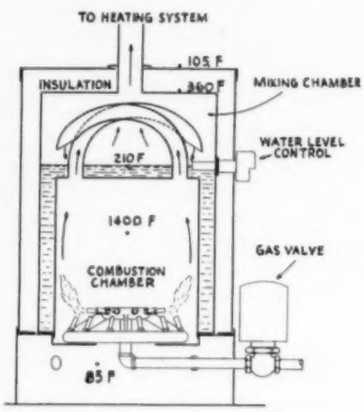


Fig. 1—Interior view of generator

Fig. 1 shows a cross section of the generator. A round burner which projects up slightly into the combustion chamber is bolted to the detachable base. Air for combustion is supplied through holes in the base below the burner. The products of combustion, after giving up some of their heat to the surrounding water jacket, are drawn up through the curved tubes and mixed with steam in the mixing chamber.

Fig. 7 shows the external view of the generator connected to the test apparatus. Its dimensions are approximately 18 in. in diameter and 28 in. high. It is well insulated with mineral wool contained in a steel shell, and stands upon the steel base which contains the burner, pilot, gas valves, etc. The fuel input capacity using natural or manufactured gas is 100,000 Btu per hour for each unit.

Description of System

Fig. 2 shows a sketch of the copper tubing arrangement together with the generator used for the tests. The generator, operated with manufactured city gas, was so arranged that the gas-vapor mixture flowed from the generator through the upright section of tubing from the top of the generator, through two parallel tube loops, 1 and 1A. From these loops the gas-vapor mixture flowed through another tube loop, 2, in series with the first two, through the radiator and through two more loops, 3 and 4, in series. At this point the products of combustion are separated from the condensate and drawn through a pressure blower of 5000 cu ft per hour capacity which is driven by a ⅛ hp motor, while the condensate flows back to the generator. From the blower the products of combustion are forced through the condenser,

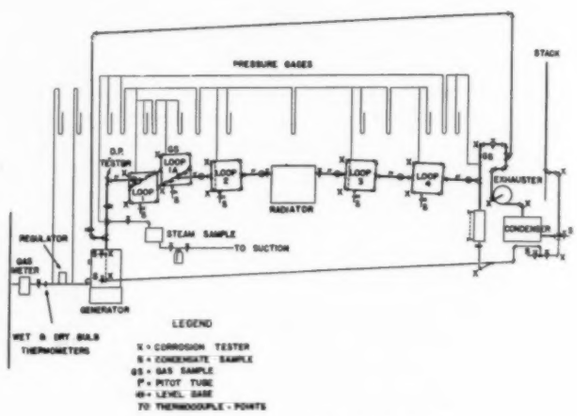


Fig. 2—Diagram of test set-up

the non-condensable gases passing to the atmosphere and the condensate formed in the condenser returning to the generator. In this test apparatus, a by-pass was used to pass some of the gas-vapor mixture directly from the generator to the exhaust fan so that both the volume of gas-vapor mixture flowing through the system itself and the amount of excess air could be varied.

Corrosion test specimens were inserted into the entrance side at the top and bottom of each loop. (See Fig. 2.) Fig. 3 shows the loop location and the corrosion testers used. These are composed of two cleaned annealed copper wire coils, of 0.05 in. diameter wire, 11/32 in. in diameter, weighing about five grams each. These coils were held in a brass frame by insulating micarta couplings. The brass frame was protected with a non-corrosion paint. The coils were weighed before and after each test, and from the loss in weight the corrosion rates were calculated.

Fig. 3 also indicates the locations of the thermocouples used to measure the temperatures. All temperatures were taken at a central point, the thermocouple wires being led to a special switch. The same sketch shows the points in the system where pitot tubes were inserted periodically for the investigation of velocity conditions. The pressures at various points were registered by U-tubes and by inclined draft gages. The set-up was designed

*Professor, Mechanical Engineering, Michigan College of Mining and Technology.
†Research Engineer, Michigan College of Mining and Technology.
[1]Using Gas-Vapor Mixtures for Heating Purposes, by C. A. Dunham, A.S.H.V.E. TRANSACTIONS, Vol. 37, 1931.
[2]Corrosion Studies in Steam Heating Systems, R. R. Seeber, F. A. Rohrman and G. E. Smedberg, A.S.H.V.E. TRANSACTIONS, Vol. 40, 1934. and A.S.H.V.E. JOURNAL SECTION, *Heating, Piping and Air Conditioning*, February, 1936.

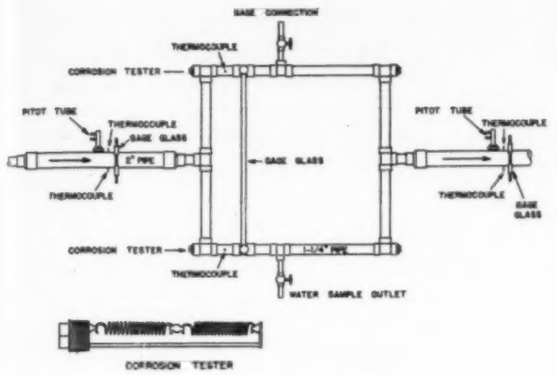


Fig. 3—Corrosion test loop

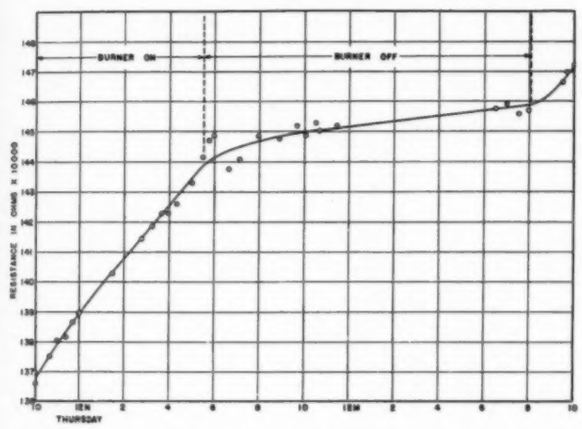


Fig. 4—Corrosion test using resistance specimen in exhaust gases

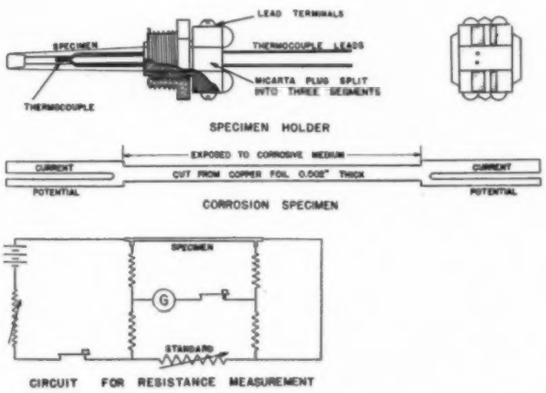


Fig. 5—Resistance method of corrosion measurements

to allow extraction of gas samples at the beginning and at the end of the system. Water samples for analysis were drawn off in order that conditions existing at each corrosion tester location might be recorded. Studies of both gas-vapor and condensate phases were thus arranged for.

In general, the set-up of the gas-vapor system is simple, as no radical change from general heating practice involving any complicated piping is necessary. The only visible differences are the decrease in size of the heater for its capacity, and the absence of the flue pipe, or smoke pipe from the boiler. For average installations a 2 in. flue pipe is necessary to carry the cooled products of combustion to the outside.

In this type of system, the products of combustion are mixed with the steam in the steam dome of the generator. In this way a gas-vapor mixture is formed, and the sensible heat in the products of combustion is used. This increases efficiency as the gross heat value of the fuel is utilized instead of the net heat value. The low temperatures attained in the system cause the water produced by hydrogen combustion to condense and give up its latent heat before being exhausted to the atmosphere. Also, this additional amount of condensation formed not only keeps the generator water level constant, but causes an oversupply of water which overflows at the generator and so flushes the entire system.

Gas of an average heating value of 530 Btu per cubic foot and carrying an average of 108 grains sulphur per 100 cu ft was burned for comparative tests at an average rate of 83.6 cu ft per hour with practically no excess air. Other tests were made with excess air and at higher and lower gas rates.

Data collected at nineteen points in the system recorded changes in conditions as the gas-vapor and condensate proceeded from generator to exhaust. The following items were recorded at the necessary locations:

Temperature of gas-vapor phase and of condensate.
Pressure (vacuum in inches of water).
Velocity of gases, feet per second.
pH value of condensate.
Condensation rate, cubic centimeters per minute.
Oxygen in gas-vapor and in the condensate.
Carbon dioxide in gas-vapor and in the condensate.
Chemical analyses, including copper, sulphate, sulphite, carbonate, chloride, total acidity.
Corrosion rate, both in condensate and in the gas-vapor phase.

Dew-point readings of the gas-vapor mixture in the combustion zone, top of the generator main, before the radiator, and at the end of the system, were obtained by a method devised by H. F. Johnstone of the University of Illinois. The principle involved in this method is the increased electrical conductivity of the film on the surface of glass upon the deposition of moisture (Fig. 6).

An electrical resistance method for measuring corrosion similar to the apparatus used by J. C. Hudson[1] of England was used in this work, and further enlarged upon. (See Fig. 5.)

In another paper[2] submitted before this Society, a detailed description of the principle and functioning of this method is given. The tests conducted on this gas-vapor system were made preliminary to the construction of this further advanced method. The principle remains the same; the only variation being that the temperature effects were corrected not automatically but by observation and mathematical adjustment of readings taken.

Fig. 4 shows some of the typical results obtained from tests in the exhaust line. The plotted results of these tests show the effect of various operating characteristics. In general, these results substantiate the corrosion results as indicated by gravimetric means. These resistance curves were of assistance in predicting the probable normal system corrosion rate. With the burner off, the corrosion rate becomes less than one-fifth the rate with the burner on. It also appears that protective films form with time and give even lower values.

The first of the three principal tests was conducted with practically no excess air used for complete combus-

[1] Atmospheric Corrosion of Metals, Bulletin of the *British Non-Ferrous Metals Research Association*, May 25, 1929.

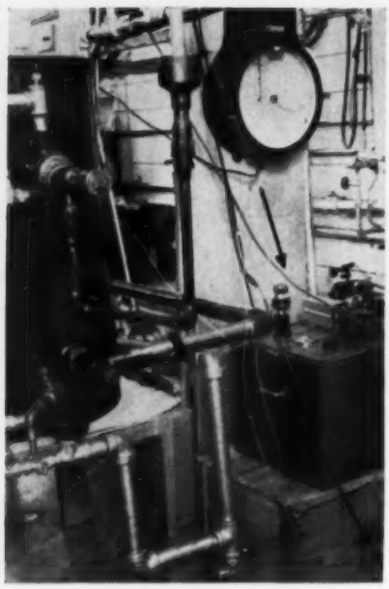


Fig. 6—Dew point apparatus

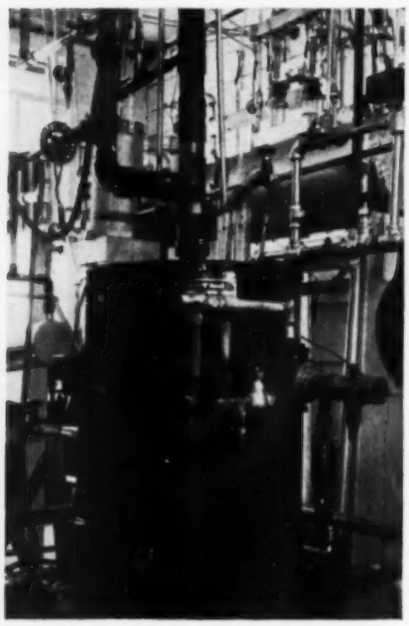


Fig. 7—External view of generator

tion—the oxygen content varying from 1.3 per cent at the top of the generator to 0.5 per cent at the condenser outlet—the CO_2 content remaining practically constant at 12 per cent, decreasing slightly. No CO was detected.

Temperatures for the generator are shown in Fig 1. Temperatures of gases in piping were about 185 F entering the radiator, and 85 deg in the piping following the radiator, with an average stack reading of 80 F. Temperatures with excess air are comparatively lower (see Fig. 8), although heating-up characteristics are still quite rapid.

Some other typical data found are: Pressure of ¼ in. of water vacuum at the top of the generator, and ¾ in. of water vacuum at the condenser outlet. The minimum pH values found were 3.5 for the condensate of the generator, increasing to 4.2 in the piping, and decreasing to 3.2 in the condensate from the condenser. Oxygen in the condensate was 0.6 cubic centimeters per liter in the bottom of the generator, around 1 cubic centimeter per liter in the piping and decreased to zero at the condenser. Free CO_2 in the condensate at the generator was 240 parts per million decreasing sharply to 40 ppm in the piping, and increasing slowly to 125 ppm in the condenser. Copper in the condensate was 0.05 grams/liter in the generator, decreasing to 0.027 grams/liter in the system and to 0.01 grams/liter in the condenser condensate. Other chemicals were determined and recorded periodically. The condensate in all cases was remarkably clean in appearance at the end of each complete test. Dew point at the top of the combustion zone was 123 F using minimum excess air.

Some long time analyses were made of two actual installations operating throughout the previous winter season, in which the metals used were largely copper-steel alloys, and the condensate conditions were similar to laboratory findings. It appears that pH values become stable with time and not more acid. Fig. 13 shows typical values, which were confirmed at the end of the season.

Durability

The question of the life of the piping, radiation, and steam generator in heating equipment using the piping and radiation as a combined passage for the flue gases and condensing vapors is evidently one of vital importance. Those who saw the equipment for the first time as it was prepared for test freely predicted an extremely short life. Such predictions might be expected from results of ordinary low temperature flue practice.

The figures show the arrangement of the equipment for testing the corrosion rates.

Data have already been given showing typical chemical conditions.

The maximum corrosion rate found in the condensate under constant operation of the test set-up was at the bottom of the generator, where it amounted to a penetration in copper of 0.004 in. per year. The average rate of corrosion in the condensate was 0.001 in. penetration per year in copper.

The maximum corrosion rate found in the gas-vapor phase was at the gas outlet of the condenser; it amounted to 0.0083 in. penetration per year in copper. The average rate of corrosion in the gas-vapor phase in the piping system was 0.005 in. penetration per year in copper.

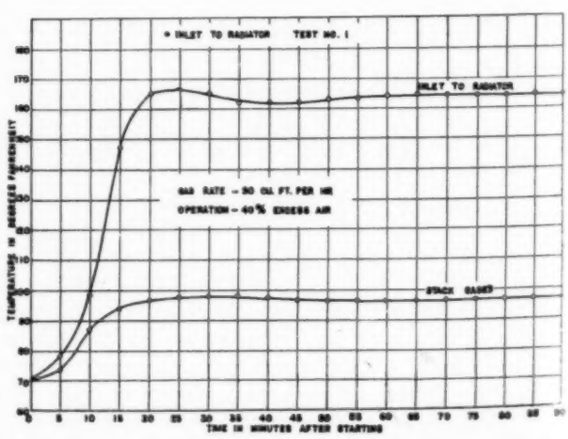


Fig. 8—Heating up characteristics of gas-vapor generator

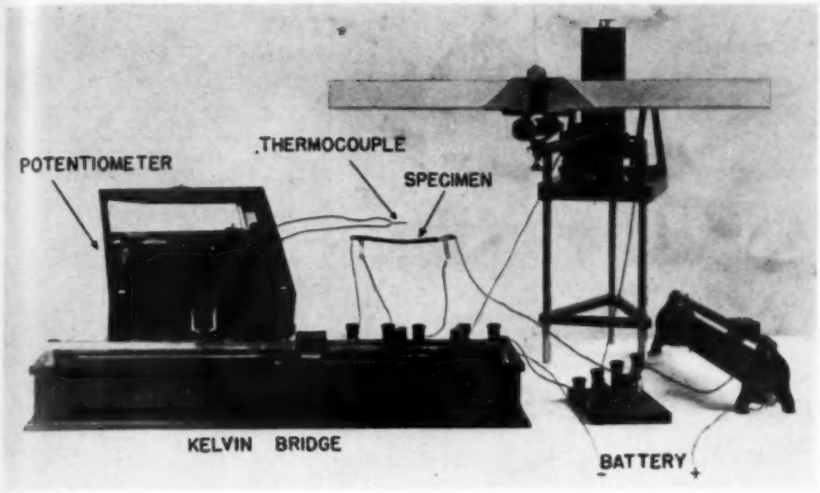


Fig. 9—Resistance corrosion testing apparatus

These rates are from the test using minimum excess air. In tests with excess air these rates are somewhat higher in the condensate and lower in the gas-vapor phase, but such changes make no material difference in the conclusions drawn. In practice, operation would ordinarily be carried on with minimum excess air. However, even the excess air tests show sufficient normal life values.

Obviously these corrosion rates indicate no difficulty from corrosion when copper piping and radiation are used, and indicate life for medium wall tubing beyond that now obtained in ordinary steam systems when using iron piping.

In estimating probable life of piping it should be borne in mind that a house heating system is usually out of service some months in the year, and with the off and on type of gas burner, gases are being circulated only perhaps one fifth of the time the plant is in commission. Fig. 4 shows the reduced corrosion rate in the gas-vapor phase with burner off and system standing idle.

These tests, it is believed, establish the fact that corrosion in a system such as that described is less than in an ordinary heating system using average steam with iron piping, but the reasons why this result is obtained should certainly be discussed.

That the sulphur content of gases and coals has caused corrosion difficulties in metal flues is common knowledge, and much has been written on the subject. With the usual long metal stack, a large volume of gas and a gradually falling temperature, it is easy to visualize the forming of drops of condensate on the walls which might finally become concentrated sulphuric acid. Johnstone (University of Illinois) has shown that possibly up to 80 per cent acid may form under usual low flue temperature conditions, and that maximum corrosion is ordinarily obtained with about 30 per cent acid. The average sulphur content of manufactured gas in this country is probably about 25 grains per 100 cu ft of gas. The gas used in the tests which this paper reports had a sulphur content of 108 grains per 100 cu ft. Ordinary combustion practice has given flue corrosion with low stack temperatures and has at times presented a serious problem with sulphur content of gas as low as 17 grains per 100 cu ft.

In these tests the maximum sulphate concentration was in the generator and, where even if the total sulphates present were calculated as H_2SO_4 the acid strength would be only 0.06 per cent. The system itself showed only about one-fifth this amount of sulphate in the condensate.

The dew point found to exist in a flue gas does not correspond with that calculated if small amounts of SO_2 are being converted to SO_3. Johnstone found that an increase of 0.008 per cent in the SO_3 content caused an increase in the dew point temperature of the actual over the computed dew point of 125 F. Maconachi[4] found an increase of the dew point of 36 F for flue gases using 66 per cent excess air in burning Toronto city gas containing 12 grains of sulphur per 100 cu ft of gas. This rise of dew point was caused by the presence of only 4 parts of SO_3 per million parts of flue gas by volume.

In these tests dew point readings were taken in the combustion zone and at the top of the generator and at

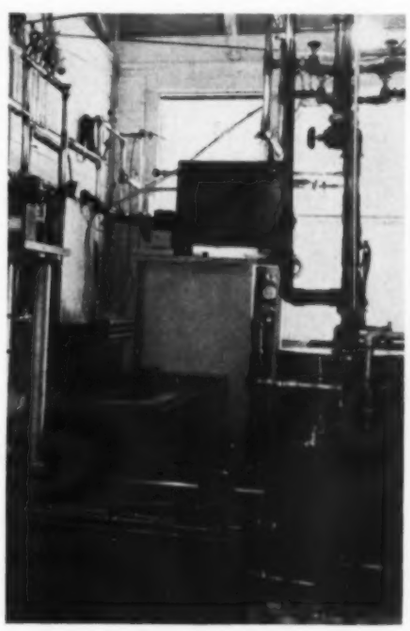


Fig. 10—View of test apparatus

points in the system, with but slight increases in the actual observed dew points above those calculated, indicating a very low conversion from SO_2 to SO_3 by this combustion process. Chemical analyses of the condensate in the system confirmed these results.

The reasons why there is such a small amount of conversion of SO_2 to SO_3 are probably as follows: Copper acts in some degree as an inhibitor of such conversion, and the temperature and time elements are not such as to cause much conversion. In addition, ample moisture is formed to wash out corrosive films,

[4]Research Fellow in Gas, Ontario Research Foundation, Toronto, Canada.

so that no localized concentrations can form and remain at any point, as is possible at times in ordinary flues under slight condensing effects.

Efficiency

Efficiencies based on the complete combustion and on losses in the flue gases at exhaust temperatures and in the overflow water, are tabulated in Table 1.

Table 1—Test Results

	Test No. 1	Test No. 2	Test No. 3	Test No. A
Excess Air	4%	40%	20%	3%
Overflow Temperature, deg Fahr.	202	194	185	130
Flue Gas Temperature, deg Fahr.	80	98	80	126
Gas, cubic feet per hour	84	84	65	139
Efficiency	99%	96.2%	99%	94.6%

The first three tests (1, 2 and 3) show very high efficiencies, with the further advantages that the conditions making for these efficiencies were consistently maintained. It seems that it is possible and practicable to obtain complete combustion with very little excess air using this equipment and proper controls, and to maintain these conditions throughout the season.

Test *A* was run for a short period at a high gas rate to see what effect this would have on stack gas temperatures and efficiencies. It appears entirely reasonable to expect efficiencies of well over 90 per cent, even with improper operation involving excess air, since the stack temperature may safely be kept low with this process.

Summary and Conclusions

Copper pipe and fittings using the soldered joints seem particularly adapted for the gas-vapor system. Corrosive action is materially less, installation costs have been found to be less than with screwed fittings and cost of materials is at present about equal when metal thicknesses and similar factors are taken into account. Improved fittings and methods of joining copper tubing have brought this material into wide usage.

The probable life value for the materials in this type of system appear to be in the usual range for heating equipment. Under the conditions of these tests none of the copper specimens showed any visible signs of pitting; therefore it seems permissible to use the average corrosion rate values in predicting the probable normal life. The fact that protective films form upon the metal with time as evidenced in the resistance tests, and that gases of high sulphur content were used for testing, allow additional safety factors for these predictions.

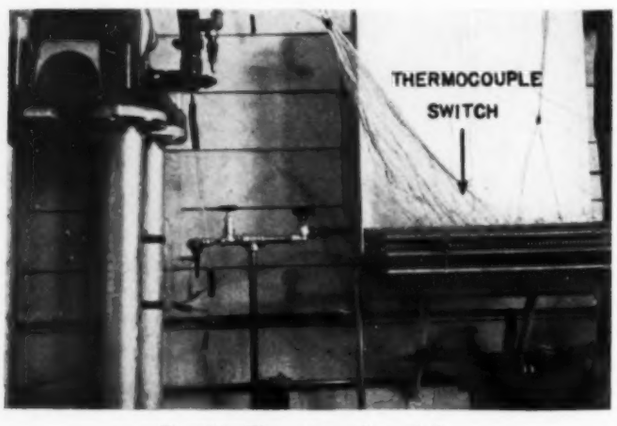


Fig. 11—Thermocouple switch

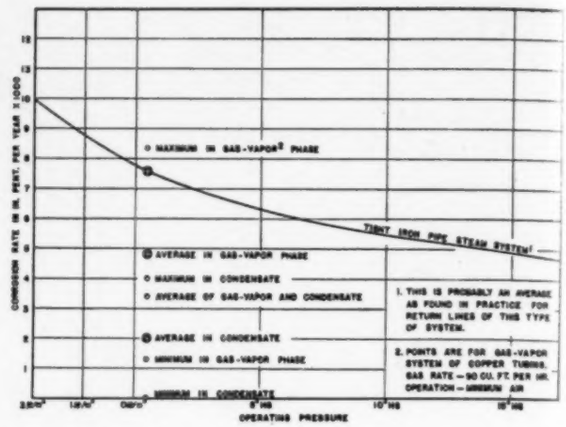

MAXIMUM IN GAS-VAPOR PHASE
TIGHT IRON PIPE STEAM SYSTEM
AVERAGE IN GAS-VAPOR PHASE
MAXIMUM IN CONDENSATE
AVERAGE OF GAS-VAPOR AND CONDENSATE
AVERAGE IN CONDENSATE
MINIMUM IN GAS-VAPOR PHASE
MINIMUM IN CONDENSATE
1. THIS IS PROBABLY AN AVERAGE AS FOUND IN PRACTICE FOR RETURN LINES OF THIS TYPE OF SYSTEM.
2. POINTS ARE FOR GAS-VAPOR SYSTEM OF COPPER TUBING. GAS RATE — 90 CU. FT. PER HR. OPERATION — MINIMUM AIR
OPERATING PRESSURE

Fig. 12—Comparative corrosion rates of gas-vapor and steam systems

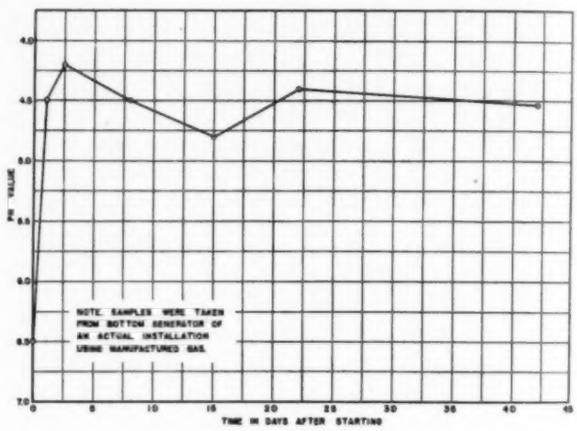

NOTE. SAMPLES WERE TAKEN FROM BOTTOM SECTION OF AN ACTUAL INSTALLATION USING MANUFACTURED GAS.
TIME IN DAYS AFTER STARTING

Fig. 13—Variation of pH value

The condensation problems often found in ordinary flues are eliminated by reason of the presence at all times of sufficient moisture for dilution of films on the metal surfaces. These films, which would ordinarily soon become highly concentrated with sulphuric acid, are being constantly washed towards the drain while the system is in operation. Fig. 4 shows, by the reduced rate of electrical resistance in the test specimen, the reduced corrosion rate in the gas-vapor phase with the burner off.

In studying this heating process several operating characteristics deserve attention.

(1) The mechanically induced draft maintains definite combustion relationships under weather and chimney variations.

(2) It is possible and practicable to use low stack temperatures which allow high operating efficiencies, even with excess air.

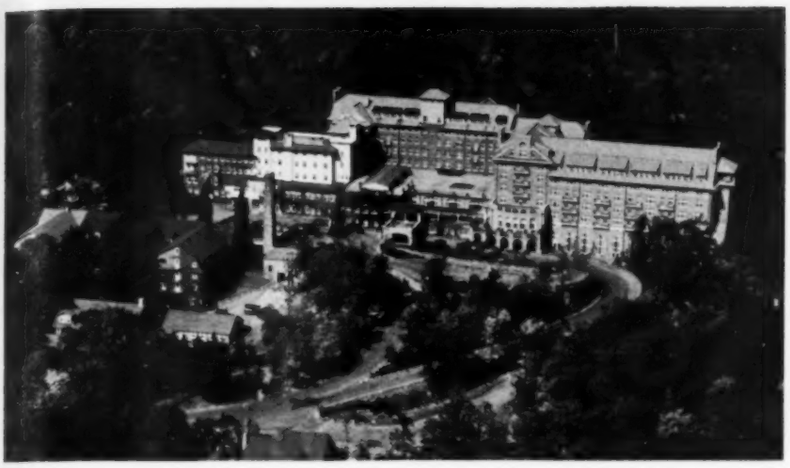
(3) The system heats up rapidly because of the relatively small amount of water contained in the generator and because the products of combustion themselves are drawn through the radiators.

(4) Since the system is open at both ends there is no opportunity for interior pressures to build up.

(5) Operation under a slight vacuum allows no moisture or gases to enter the room.

Acknowledgment

Acknowledgment is due to H. V. Williamson for work carried on with the electrical resistance method.



The Inn at Buck Hill Falls

A. S. H. V. E.

Semi-Annual Meeting

Buck Hill Falls, Pa.

June 22-23-24

WE EXTEND A CORDIAL INVITATION TO COME TO THE POCONOS IN JUNE

Philadelphia Chapter again will be your host. The following committees have planned for your entertainment and they want you to save the dates and come!

R. C. Belsinger

General Chairman, COMMITTEE ON ARRANGEMENTS

You will have three days of living as you have always wanted to live.

Wilbur J. Smick

Vice-Chairman, COMMITTEE ON ARRANGEMENTS

• • •

As Chapter President I extend a most cordial invitation to the members of the Society and their friends to attend this meeting.

As Chairman of the Entertainment Committee I promise every effort will be made to make the visit interesting, enjoyable and profitable.

Jos. Hucker

President, PHILADELPHIA CHAPTER
Chairman, ENTERTAINMENT COMMITTEE

• • •

We will have facilities for registering a large attendance and hope our expectations are exceeded.

Harry J. Black

Chairman, REGISTRATION COMMITTEE

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To the ladies we offer everything they desire. A three-day calendar of enjoyable events.

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The Banquet with its excellent food, incomparable music and world famous Adelphia Quartet will leave nothing to be desired.

A steak-fry on the mountain top staggers the imagination!

Merrill T. Blankin

Chairman, BANQUET COMMITTEE

• • •

Golf—and plenty of it on one of the most picturesque courses you ever played. Prizes—and plenty of them too!

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Chairman, GOLF COMMITTEE

• • •

Money can't buy a better outing, yet the cost is so low your budget won't feel it.

Lee P. Haynes

Chairman, FINANCE COMMITTEE

• • •

The committees are sincere in their promises—yet rather modest because Buck Hill Falls provides a background for a real outing for the entire family. You really can't afford not to come. Watch for further announcements!

Harry Erickson

Chairman, PUBLICITY AND TRANSPORTATION COMMITTEE

Award of F. Paul Anderson Medal to Dr. A. C. Willard

One of the outstanding events at the 42nd Annual Meeting of the A.S.H.V.E. in Chicago, Ill., was the award of the F. Paul Anderson Medal to Dr. A. C. Willard during the Society's Annual Banquet at the Palmer House, on January 29. The presentation of the gold medal and certificate was made for the Committee on Award by John Howatt, Chicago, Ill., who was president of the A.S.H.V.E.:

During my term as President, I have had many pleasant duties to perform but none that gives me more satisfaction and more pleasure than the one that now comes to me.

The Committee, that was appointed to determine the one whose work and accomplishments had earned him the right to the award of the F. Paul Anderson Medal, by their unanimous vote,

selected Arthur Cutts Willard as the one most worthy above all others to receive this award. An award that is indicative of outstanding leadership, accomplishment and service in the field of Heating, Ventilating and Air Conditioning.

For 25 years Dr. Willard was engaged in this field as an author, teacher, engineer and research director and in that time contributed much that was of influence in its progress and development. He contributed so much and so well that he came to be recognized as an authority in many of its divisions. Some of his work had direct application in human ease and comfort, and so contributed to the science of better living. His accomplishments for which the award is made are set forth in this certificate. They are as follows: "In recognition of his achievements in the fields of heating, ventilating and air conditioning as an Engineer, Educator and Author; For his pioneer research work and outstanding services to the Society as Member, Officer, and Research Adviser."

His record discloses his activities covered a wide field of engineering. However, the A.S.H.V.E. gained more perhaps from his talent and genius than any other engineering organization. Joining this Society as a Member in 1914 he served as member, as member and chairman of many of its most important committees, on its Council, as an Officer, President and Adviser to its research program; he brought as much honor to each position as it brought to him.

He is now engaged in a field that will give even greater opportunities for service than the field he left. Knowing him as we do we are confident none of these opportunities for service will be overlooked. When his worth was recognized by the University of Illinois in promoting him to the Presidency of this great University his friends knew that, while the A.S.H.V.E. was being complimented by having one of its past presidents and one of its outstanding members selected for the position of honor and trust, the State of Illinois was itself to be congratulated on the choice made by the trustees of the University. The work already done in the short time he has been president demonstrates the wisdom of the choice and is indicative of the good things in store for the institution in the years to come. We are confident we will be as proud of his work in this newer field as we are of the work he did in the field of heating, ventilating and air conditioning for which he is now being honored.

So Dr. Willard, it is with complete satisfaction and a great deal of personal pride that by direction of the A.S.H.V.E. I present you with the F. Paul Anderson Medal and Certificate. We trust you will find as much joy and happiness in their possession as we do in their award.

The work of Dr. Willard in heating and ventilating research has received world-wide acclaim and his best known work has been in the fields of heat transmission, steam flow and warm-air heating. His work as ventilating consultant with the late Clifford M. Holland, resulted in the development of a new ventilating principle first used in the Holland Tunnel and since adopted for later constructions of similar kind. He was a pioneer in warm air furnace heating research and through his untiring efforts, a residence for research purposes was constructed at the University of Illinois.

Dr. Willard was born in Washinghton, D. C., and after receiving his preparatory education in the public schools of the District of Columbia he was a student at the National College of Pharmacy from 1898-1900. He attended Massachusetts Institute of Technology and was graduated in 1904 with the degree of S. B. in Chemical Engineering. He commenced his teaching career immediately in California and in 1906 became assistant professor of mechanical engineering at George Washington University. From 1909 to 1913, he served the Government as sanitary and heating engineer, in the office of the Chief Quartermaster of the Army. In more recent years he has also served the U. S. Bureau of Mines, the Chemical Warfare Service of the Army and the Architect of the Capitol as adviser on heating, ventilating and air conditioning problems.

Dr. Willard was a faculty member of the University of Illinois from 1913 to 1934, first as assistant professor of heating and ventilating, then in 1917 he became professor of mechanical engineering and in 1920 became head of the department of heating and ventilation. During the war, Dr. Willard acted as consultant for the U. S. Army and then returned to his duties at the University of Illinois.

Dr. Willard is the seventh president of the University of Illinois and took office July 1, 1934. In 1934 he received the degrees of D.Eng. from Case School of Applied Science, LL.D. from George Washington University and LL.D. from Northwestern University. He holds membership in many engineering and scientific bodies in addition to the A.S.H.V.E., including the following associations: *American Society of Mechanical Engineers, Society for Promotion of Engineering Education, American Society of Refrigerating Engineers, National Warm Air Heating and Air Conditioning Association,* and the *Illinois Society of Engineers;* he is a member of the following fraternities: Sigma Xi, Phi Kappa Phi, Tau Beta Pi, Triangle, Sigma Tau, Pi Tau Sigma, Omega Chi Epsilon, Phi Eta Sigma, Phi Kappa Sigma. He is a member of the following Clubs: Chicago Engineers Club, University Club of Chicago, University Club of Urbana, Chaos Club of Chicago, Urbana Rotary Club and Champaign-Urbana Kiwanis Club.

In the American Society of Heating and Ventilating Engineers he has served on many of the Technical Committees, including the Guide Publication Committee, Committee on Ventilation Standards, Committee on Code of Minimum Requirements for the Heating and Ventilation of Buildings and he has held the offices of President, First Vice-President and Second Vice-President. For a number of years he was a member of the Council and was Chairman of the Executive, Publication and Program Committees. For several years he was a member of the Committee on Research and since 1931 has been Technical Adviser for Research.

Dr. Willard has been the author of several books and numerous papers from his pen appear in the Society's Transactions. He has compiled many bulletins reporting research investigations which he has directed and he has also been a frequent contributor to engineering publications. With L. A. Harding, he is co-author of Mechanical Equipment of Buildings, first published in 1916 and Heating, Ventilating and Air Conditioning published in 1932.

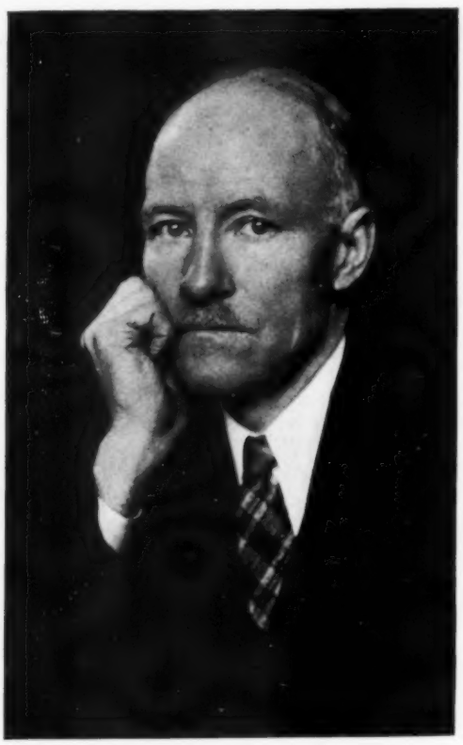
The F. Paul Anderson Medal Committee on Award for 1935 consisted of Prof. G. L. Larson, University of Wisconsin, Madison, Wis., H. P. Gant, Philadelphia, Pa., L. A. Harding, Buffalo, N. Y., S. R. Lewis, Chicago, Ill., and W. E. Stark, Cleveland, Ohio.

Introducing the New Research Chairman

At the organization meeting of the 1936 Committee on Research of the A. S. H. V. E., W. A. Danielson was elected Chairman. He is an officer in the Quartermaster Corps of the United States Army, with the rank of Lieutenant Colonel, and is stationed in Washington, D. C.

Colonel Danielson graduated in electrical engineering at the Iowa State College, Ames, Iowa, in 1907, and in 1926 received the degree of M. S. from the Massachusetts Institute of Technology after a year of special work.

After graduation from Ames he was for one year with the General Electric Co. as an apprentice at Schenectady, N. Y. He then took the necessary examination and was commissioned in the Coast Artillery Corps of the United States Army. He



Col. W. A. Danielson

resigned from the Army in 1913 and was re-commissioned in 1916. In 1917 he was transferred to the Field Artillery and served with that branch during the war. On his return from France in 1919 he was assigned to construction work in the Philippine Islands, which work included the building of two air stations and a number of other isolated buildings in addition to the regular maintenance and operation of all Army stations and utilities in the Islands. Upon his return from the Philippines in 1921 he was assigned to the Quartermaster General's office in charge of maintenance and operation of all Army stations. He continued on this work either in the War Department or at Corps Area Headquarters until 1932, except for one year spent at the Massachusetts Institute of Technology. In 1932 he was assigned to new construction work and has been on that work either in the Quartermaster General's office or in the field to date. In 1933 he was placed in charge of the New Construction Branch of the Quartermaster General's office, and his work included the designing and contracting for about $50,000,000 of buildings and utilities. The organization at that time consisted of 240 architects and engineers in addition to the clerical force.

The first heating work in which Colonel Danielson was engaged was the installation of a hot water gravity system in a greenhouse. He was not only the designing engineer on this job but also wielded the tools that installed the piping and boiler. Next, as Quartermaster at a large Army station he had charge of the operation of a large number of heating plants and a steam power station, together with a number of small steamers.

When he left the Army in 1913 he became assistant general manager and electrical engineer for a power system in the Northwest, in charge of the construction of something over 100 miles of transmission lines, sub-stations, etc., from 66,000 volts down.

His work since the World War has had to do with all phases of engineering and construction. Heating, and lately ventilating and air conditioning, have become such important elements in both construction and operation that a great deal of his time and attention has been devoted to these subjects.

Colonel Danielson has had the opportunity of contacting engineers in every line of endeavor and he brings to the Committee on Research a viewpoint that includes not only heating but also an intimate knowledge of all other construction details. Added to this he has a highly developed sense of cooperation which is so essential in carrying out work that involves such a wide organization as that of the Committee on Research. Since his election as Chairman of the Committee he has been making an intensive study of the whole research program. So far he has visited the University of Illinois, the Iowa State College, the A. S. H. V. E. Research Laboratory at Pittsburgh, Harvard, the Massachusetts Institute of Technology, Yale and the Pierce Laboratory at New Haven, and has surveyed activities around New York.

Colonel Danielson is a member of the *American Institute of Electrical Engineers* (which he joined in 1906), the *Society of American Military Engineers*, the Army and Navy Country Club and the Cosmos Club, of Washington, D. C., and the Army and Navy Club of Manila, P. I.

Representative on A. S. T. M. Corrosion Committee

Pres. G. L. Larson announced the appointment of Dr. James Aston, Pittsburgh, Pa., as A. S. H. V. E. representative, and A. E. Stacey, New York, N. Y., as alternate on Committee D-19 of the *American Society for Testing Materials*. The scope of this committee's activities is to study water used for industrial purposes, interpret the results of tests and develop standard methods of sampling and analysis, nomenclature, terminology, classifications and specifications. The committee's work deals with the use of water in boilers and during a meeting held in Pittsburgh the first week in March there was a discussion relating to corrosion studies in heating, ventilating and air conditioning equipment.

The chairman of Committee D-19 is Max Hecht, Pittsburgh.

12th National Oil Burner Show

The Twelfth National Oil Burner Show is scheduled to be held at Detroit, Mich., April 14-18, and the officials of *Oil Burner Institute* anticipate a record-breaking attendance not only of oil burner and accessory manufacturers and dealers but of the public, and are assured of a greater number of exhibits than at any previous oil burner show. G. Harvey Porter is managing director and has announced the convention and show program.

Beginning Tuesday, April 14, afternoon and evenings of every day through Saturday will be given to the Show at Convention Hall, Detroit. Speakers announced for the merchandising session Thursday morning are D. G. Valentine, N. W. Ayer & Son, who will speak on Market Analysis; Ralph Beale, of Norge Corp., on Salesmanship; and W. C. Wood, of Timken Silent Automatic Co., on Financing. Mr. Porter will act as chairman and there will be open discussion. At the annual banquet and

dance Friday evening Gar Wood will be the principal speaker and R. S. Bohn, of Preferred Utilities Manufacturing Corp., will act as toastmaster.

Refrigerating Machinery Manufacturers Call Meeting

The *Refrigerating Machinery Association* will meet on May 14, 15 and 16, at Hot Springs, Va., according to a recent announcement of Pres. D. N. Benedict. At this Spring meeting, it is anticipated that much of the discussion will concern the forward-looking standardization program which the Association has undertaken and on which substantial progress has been made during the past year.

Air Conditioning Manufacturers to Meet

Pres. P. A. McKittrick has announced that the *Air Conditioning Manufacturers' Association* will hold its Annual Meeting at Hot Springs, Va., on May 16. Closing a year which has been marked by progress in the interest of the air conditioning industry, the Association is planning an even broader program of constructive work.

Short Course on Warm Air Heating and Cooling at Michigan State

The Fourth Annual Short Course on Warm Air Heating and Cooling was held March 31 through April 3 at Michigan State College, East Lansing, Mich., under the auspices of the *National Warm Air Heating and Air Conditioning Association* of which J. H. Van Alsburg, Holland, Mich., is chairman of the Technical Education Committee.

The course included a study of the theory necessary for making calculations for a complete air conditioning installation in an insulated home and the information was presented in practical form based on data contained in THE A. S. H. V. E. GUIDE. The instructors in charge of classes were selected from those engaged in the air conditioning industry and were well versed in their particular subjects.

Cleveland

January 13, 1936. Twenty-eight members and Dr. C. A. Mills, Cincinnati, Ohio, who was guest of honor, attended the dinner and business meeting at the Cleveland Club. The minutes of the December meeting were read and accepted and new business was then in order.

A letter from W. E. Stark told of his attendance at meetings of the Illinois and Minnesota Chapters of the Society.

Announcement was made in regard to the Exchange Service Plan with the *American Society of Refrigerating Engineers,* arranged by the Council, and outlined in a letter from A. V. Hutchinson, secretary of the A.S.H.V.E. Mention was also made of the recommendation that the Society hold a joint meeting with the *A.S.R.E.*

M. F. Rather discussed the program of the 42nd Annual Meeting of the A.S.H.V.E.

Treas. H. M. Nobis reported totally liquid assets as of January 31, 1936 amounting to $420.47, plus $162.05 not so liquid, making the total assets of the Chapter $582.52.

R. A. Wilson of the Membership Committee proposed the following members who were accepted into the Chapter: J. P. Jones, W. R. Rhoton, Philip Borkat, E. E. Stewardson, L. B. Oaks and J. H. Bauman.

The date of the February meeting was announced by F. R. Dickenson of the Program Committee.

H. E. Wetzell of the Standards Committee then discussed the Proposed Standard of Rating and Testing Air Conditioning Equipment.

Mr. Rather introduced a resolution outlining the faithful service of Earl J. Vermere, deceased Vice-President of the Cleveland Chapter, and it was moved that the resolution be accepted and suitably engrossed for transmission to Mrs. Vermere.

The business meeting then adjourned and an open meeting was held at the Cleveland Medical Library Auditorium with an attendance of approximately 400, including members of the Electrical League and members of the Academy of Medicine.

Dr. C. A. Mills, professor of Experimental Medicine at the University of Cincinnati, was the speaker and discussed the Physiological Aspects of Air Conditioning, illustrating his talk with slides. The audience was deeply impressed with the studies of Dr. Mills which indicated a direct relation between health, fertility and weather.

There were no official minutes for the February 14 meeting as this was purely a fun meeting with no business discussion permitted. Secy. Philip Cohen reports that he regrets sincerely his absence on this occasion, but has been given to understand that the present administration of the Chapter was bypassed, recirculated and properly conditioned during the course of the meeting.

Illinois

March 9, 1936. Pres. J. H. Milliken called the meeting to order at 7:55 p. m. in the Hotel Sherman, Chicago, with 70 members and guests present. Secy. L. S. Ries read the minutes of the previous meeting which were approved.

The ballots for the selection of the Nominating Committee were presented, and President Milliken appointed the following tellers: J. E. McClellan, C. E. Price and L. J. Pitcher.

A welcome into the chapter was extended to M. W. Bishop and J. H. Needler.

Secy. L. S. Ries announced that W. B. Graves, a Life Member of the Society was celebrating his Golden Wedding Anniversary on Friday, March 13. President Milliken called on John Howatt, Past President of the A. S. H. V. E., who introduced the speaker of the evening, Dr. W. F. Petersen, Department of Pathology, College of Medicine, University of Illinois.

Dr. Petersen chose for his subject The Effect of Weather on Man and he opened his discussion by stating that the facts he was to mention during the evening were known to the Greeks, for Hypocrates wrote knowingly of the adverse effects of varying temperatures on digestion and general well being of the populace and spoke of the universal hot winds and the local hot winds as affecting large areas and small areas of the population of Greece, so that this correlation of weather on man is of ancient knowledge.

The discourse of Dr. Petersen was profusely illustrated by many lantern slides which clearly showed the many points that he wished to emphasize. A cyclonic circulation map giving the concentration of cyclonic lines in the northern United States clearly showed the path from the west coast at about the state of Washington eastward across the Rockies following roughly the Canadian boundary and leaving continental North America in a very narrow area in the vicinity of the New England states. This approximates the Van Cleeve storm track map. It showed clearly that there was a greater demand for adjustment of the human body to cyclonic storms at Duluth than at San Francisco.

Meteorologically speaking, each three or four days a meteorological episode crosses in this cyclonic area, traveling eastward across the United States. Meteorological episode is a term applied to a cold area traveling eastward with a warm area between it and the cold area still further to the east. Where the warm area and the cold area come in contact is known as the polar front. The barometric variations give an index of energy required by man to adjust himself to his surroundings. He showed clearly by curves, based on the deaths occurring in representative states, and in the United States as a whole, that this death rate varies directly with the barometric

pressure adjustment required. This is particularly noticeable at the time of the equinox in the spring and the fall. The barometric variation is the greatest at these periods and the death rate is correspondingly great. The birth rate is inversely to the death rate at these periods.

Dr. Petersen further illustrated the synchronism of the severe changes in the barometric pressure and the corresponding temperature changes with many functions of diseases and body chemistry of the human body. For instance, when the air temperature goes suddenly warm, the ph of the blood goes rapidly up. Then when the body condition is unduly alkaline it is susceptible to vascular spasm, thus directly affecting the health of individuals with heart trouble. He traced the variation of disease phenomenon in certain patients afflicted with paralysis, migraine, pneumonia, diabetes, and insanity, showing a definite relationship between barometric pressure and the well being and body chemistry of these patients. After the talk a lively discussion followed. A formal vote of thanks was voted Dr. Petersen for his interesting address.

The tellers reported the result of the balloting for the Nominating Committee as follows: J. J. Aeberly—41, J. J. Hayes—38, C. W. Johnson—38, J. H. Milliken—36, C. W. DeLand—36, Robert E. Hattis—35, W. B. Graves—30.

The meeting adjourned at 9:50 p. m.

Massachusetts

February 10, 1936. Fifty-four members and guests of the Massachusetts Chapter attended a meeting in Pierce Hall, at the Engineering School of Harvard University, which was opened by Pres. W. A. McPherson with an explanation of the proposed Professional Engineers Registration Law. All members of the Chapter were urged to cast their vote in the poll being conducted by the Engineering Societies, as the result will guide the action of the council of the associations which sponsored the bill. The discussion following seemed to indicate strong opposition to the provisions of the law.

Prof. C. P. Yaglou introduced the speaker of the evening, A. E. Kimberley, in charge of the design and operation of the air conditioning system of the new Department of Archives Building, Washington, D. C. Mr. Kimberley stated that the only factors harmful to the stored material, which are not under complete automatic control, are the ever present insects and the unavoidable required light.

In his address, Mr. Kimberley mentioned that by comparison of old books of similar issue, it was determined that paper in libraries in large cities deteriorated more rapidly than paper stored in rural districts. The cause of this was finally isolated as being the SO_2 pollution of the city air.

The speaker stated that the proper conditions of temperature and humidity, namely 70 deg in winter and 85 deg in summer, with a relative humidity of 50 per cent, were fairly well determined and capable of practical application, but it was necessary to design a method of removing the SO_2. He explained that the air washer is run continuously with the proper alkalinity automatically maintained, not only removing the SO_2 content, but also taking out the objectionable dust and odors. Fresh air is admitted only as required for the needs of the occupants.

Numerous questions were asked Mr. Kimberley concerning special features of the equipment and other related problems.

Secy. G. B. Gerrish reports that the meeting closed with a rising vote of thanks for the able presentation of an interesting subject.

Minnesota

February 10, 1936. A meeting of the Minnesota Chapter was held in the Minnesota Union, University of Minnesota, and after dinner was served at 5:30 p. m., Pres. C. E. Gausman called the meeting to order.

The minutes of the previous meeting having been read and approved, President Gausman called on Albert Buenger for remarks pertaining to the Annual Meeting of the Society in Chicago. Mr. Buenger included high lights of the technical sessions and of the Council meetings in his discussion. The change in the rate of dues for Student Members of the Society to become effective July 1 was brought out and considerable discussion followed.

A committee consisting of Prof. F. B. Rowley, Chairman, A. B. Algren, Albert Buenger, and R. E. Backstrom was appointed to look further into this matter.

The speaker of the evening, Mr. McCormick, Minneapolis, was introduced and gave a very interesting talk on Air Distribution in Rooms. Mr. McCormick discussed the subject from a technical point of view as well as the practical, calling attention to the various types of grilles which are required to bring about an even distribution of air in rooms of various size and shapes. The address invited many questions which were ably answered by the speaker.

According to the report of Secy. R. E. Backstrom 35 members and guests were present.

New York

February 17, 1936. At the February meeting of the New York Chapter, held in The Building Trades Club, the subject of Prevention of Domestic Water Pollution from Heating and Air Conditioning Equipment and from Waste Water was discussed by Louis Northon, consulting engineer.

Mr. Northon stated that every day practice in heating, air conditioning and hot or cold water supply requires a thorough knowledge of hydraulics with special attention to pressure fluctuations within water supply mains. The speaker discussed at length the ebb and flow of the tides in water mains and illustrated with slides the possibilities, probabilities, and actualities he had experienced of water pollution and infection from those who work on pipes who may be germ carriers, and from the backward flow of plumbing fixtures and heating equipment under certain conditions.

Mr. Northon mentioned that because of his long association with the Navy he felt qualified to speak on water and stated that his interest in preventing infection of water supply began while still a youth in college at Budapest, when he designed vacuum breakers for the prevention of backward flow in the water pipes of residences. Slides illustrating the device were shown and it was apparent that the problems then encountered in design and operation were more complicated than the familiar devices now used in heating. Mr. Northon's interest was aroused when the young child of one of his professors drank some washing bluing from a faucet on a riser which also supplied an attic laundry, where the hose on another faucet dipped in prussic acid. Mr. Northon discovered and reported the cause of the child's death.

The speaker related several of his experiences during the World War and tragedies which had occurred elsewhere, as a result of contamination of water supplies.

Mr. Northon told of laboratory facilities arranged in his home, where he can pour milk in a plumbing fixture and locate it outside in the water main with the assistance of the local water supply department, to illustrate what can happen when a main is tapped. Then again when milk is poured into a fixture and the corrective device is in operation, no milk can be found outside as it remains in the inside fixture.

Another subject of discussion was Tests on Large Orifice Heating Systems with Various Types of Controls. Kirby Walker and W. H. Mertens presented data they had obtained from an automatic controlled orifice system installed in a twelve-story Tudor City apartment house in New York City.

The building tested was heated with central station steam which was distributed through a two pipe gravity system with orifices inserted in the radiator inlet valves. Steam supply variations were controlled with a centrally located reducing pressure valve operated by the temperature control apparatus

which responded to the heat requirements of the building. Comparative steam consumption rates were determined with the system operating on steam introduced to the radiators in intervals of 2 and 3 min on and off by the central control apparatus actuated by radiator output; with the steam supplied for approximately 15 min periods of on and off using a time-clock; and with the steam operated at various continuous pressures to obtain different radiator outputs. Mr. Mertens acted on the test and in the talk as an impartial observer, while Mr. Walker expressed opinions and drew conclusions.

In general, Mr. Walker discussed the effect of these methods of control on the outputs of radiators in different parts of the building. He told of the new developments recently being made in heating systems whereby their inherent characteristics could be studied as a complete unit. He further pointed out that, when an entire system is made the subject of experimentation instead of tests on a single orifice or radiator, the conclusions are different. The talk introduced a new concept of radiator output expressed in per cent and after the formal presentation of the paper an interesting discussion followed.

Oklahoma City

March 9, 1936. The March meeting of the Oklahoma City Chapter was held in the library of the Oklahoma Gas and Electric Co. and the minutes of the preceding meeting were read and approved.

Pres. F. X. Loeffler introduced P. D. Close, Chicago, Ill., who spoke on the subject of Insulation and Its Relation to Air Conditioning. Lantern slides were used and Mr. Close particularly emphasized the necessity of intelligent application of insulation on the basis of the economic factors involved.

H. J. Leverance, secretary of the Chapter, tendered his resignation because of his transfer to Wichita, Kansas, and E. W. Gray was elected to fill the unexpired term of office.

A letter to the Chapter from W. A. Russell, chairman of the Society's Membership Committee, was read and urged all members to work for new members.

It was suggested that President Loeffler appoint a Chapter Membership Committee and, after the business session, action was taken naming H. W. Meinholtz, Chairman, A. D. Holmes and A. A. Hoppe.

It was also moved and seconded that President Loeffler appoint a committee to compile a set of minimum standards for air conditioning, and the meeting then adjourned at 10:00 p. m.

Ontario

March 2, 1936. The regular meeting of the Ontario Chapter was held at the Royal York Hotel, Toronto, and dinner was served at 6:30 p. m. with 27 members and guests present.

Following dinner Pres. M. W. Shears called upon Secy. H. R. Roth to read the minutes of the preceding meeting which were accepted as presented. An announcement was made that the Nominating Committee would report at the next regular chapter meeting and President Shears then called upon Cyril Tasker, the speaker of the evening, who gave a very instructive illustrated talk on Research—The Fact Finder.

Following Mr. Tasker's address, E. H. Gurney spoke on the activities of the Ontario Research Foundation in regard to air conditioning, heating and ventilating.

Pacific Northwest

February 18, 1936. Twenty-four members and guests attended the meeting of the Pacific Northwest Chapter held at the Hungerford Hotel in Seattle, Wash., when dinner was served at 6:30 p. m. and the meeting was called to order at 7:45 p. m.

The minutes of the January meeting were read and approved and Pres. Lincoln Bouillon gave a report on the 42nd Annual Meeting of the Society held in Chicago, Ill., January 27-30.

Secy. D. C. Griffin read the list of Chapter members and it was announced that the Chapter has 24 A. S. H. V. E. members, 19 local members and 36 on the courtesy list.

It was suggested by President Bouillon that a Chapter be organized in Vancouver, B. C., and that the Pacific Northwest Chapter render all possible assistance in its formation. S. D. Peterson was instructed to contact those who might be interested on his next trip to Vancouver and Secretary Griffin was requested to send a written invitation to the Society members in Vancouver to be guests at the April meeting of the Pacific Northwest Chapter when Pres. G. L. Larson will be present.

A motion was made and carried to charge a reservation fee of fifty cents, if, having been duly notified of a regular meeting, members fail to attend or notify the Secretary not later than noon the day of the meeting.

Mr. Sparks described some of the exhibits and other interesting features of the Annual Meeting and Heating and Ventilating Exposition in Chicago.

In accordance with a request from John Howatt, Chicago, Ill., a committee, consisting of Prof. E. O. Eastwood, W. L. Dudley, and President Bouillon, was appointed to make a survey and report on local weather and climatic conditions for the purpose of establishing air conditioning standards. C. W. May and Secretary Griffin were named as alternates.

Mr. Foote was requested to make a canvass of the Tacoma territory in an effort to arouse more interest there in A. S. H. V. E. activities.

After a general discussion of Chapter problems, the meeting adjourned at 9:20 p. m.

Philadelphia

March 12, 1936. The Philadelphia Chapter held its regular meeting in the Engineers Club with Pres. J. H. Hucker presiding.

J. H. LaBrum spoke in behalf of the United Campaign and asked the support of the members.

The minutes of the previous meeting and the treasurer's report were read and approved.

A silent moment of prayer was accorded the memory of C. E. Monday, who passed away March 7, 1936. Mr. Monday, although not active in the Philadelphia Chapter at the time of his death, had just been elected a Life Member of the A.S.H.V.E. and his demise occurred before plans could be carried out for presentation of his life membership certificate.

President Hucker read a communication from W. A. Russell, Kansas City, Mo., chairman of the Society's Membership Committee, stressing the importance of securing new members.

Secy. H. H. Erickson read the report of the Nominating Committee, which placed the following names on the ballot:

President—W. F. Smith.
Vice-President—L. P. Hynes.
Secretary—H. H. Erickson.
Treasurer—R. F. Hunger.
Board of Governors—J. H. Hucker, S. E. Plewes, and C. B. Eastman.

The Secretary was instructed to prepare ballots to be sent to the members at least 15 days before the time of election.

A. H. MacDade reported 28 members present at dinner and an attendance of 45 at the meeting.

A. E. Kriebel told of the progress of the publication of the Year Book and F. D. Mensing spoke of the writing of a history of the Philadelphia Chapter.

Plans for the Semi-Annual Meeting of the Society to be held at Buck Hill Falls, Pa., June 22-24, 1936, were outlined by Secretary Erickson.

Morris Sheffler then introduced the speaker of the evening, W. N. Bateman, whose paper on Liquid Petroleum for House Heating was well received.

The meeting adjourned at 9:30 p. m.

February 13, 1936. Pres. J. H. Hucker presided at the regular meeting of the Philadelphia Chapter held at the Engineers Club. The minutes of the January meeting and the treasurer's report were read and approved.

President Hucker in behalf of the Salvation Army made an announcement concerning their campaign for funds.

The cooperation of the chapter in securing members' names

and affiliation for the Year Book was urged by Secy. H. H. Erickson.

R. C. Bolsinger, Chairman of the Committee on Arrangements for the A.S.H.V.E. Semi-Annual Meeting to be held at Buck Hill Falls in June, 1936, spoke on plans for the entertainment of members and guests. Mention was made in introducing Mr. Bolsinger of his election to the Council of the Society representing the Philadelphia Chapter district.

Secretary Erickson spoke briefly on the Annual Meeting of the A.S.H.V.E. which was held in Chicago, January 27-30.

Due to the inclement weather the attendance was not up to the usual standard and it was therefore deemed to the best interest of the membership to withhold the presentation of H. H. Mather's splendid paper until the April meeting.

Following this action the meeting became informal and some interesting narratives and views were given by J. D. Cassell, F. D. Mensing, W. F. Smith, M. F. Blankin, R. F. Hunger, J. H. Hucker and R. C. Bolsinger. In all it was really an enjoyable meeting which seemed to have been adjourned too early—at 10 p. m.

Pittsburgh

March 9, 1936. Pres. R. J. J. Tennant called the meeting to order at 7:50 p. m. in the auditorium of the U. S. Bureau of Mines and Secy. T. F. Rockwell read the minutes of the February meeting, which were approved.

In the absence of J. F. Collins, Jr., the Treasurer's report was given by the Secretary.

Chairman M. L. Carr of the Program Committee announced that arrangements had not been completed for the April meeting, but that an attempt would be made to select a date which would be convenient to H. B. Meller, director of the Air Hygiene Foundation.

In speaking for the Membership Committee, F. C. McIntosh read a letter from the A. S. H. V. E. Membership Committee outlining plans for the year and a letter was also read from Secy. A. V. Hutchinson regarding membership grades and dues.

R. B. Stanger, of the Social Committee, stated that the committee hesitated to recommend the resumption of dinner meetings at the present time. He suggested the possibility of combining some other form of social activity with the regular technical sessions and this was favorably received.

It was moved by F. C. Houghten, seconded by T. M. Dugan, and passed that the Social Committee be authorized to prepare an amendment to the By-Laws which would permit greater flexibility in meeting dates, so that when necessary, meeting dates could be changed both for the convenience of speakers and scheduling suitable meeting places.

L. B. Pittock, chairman of the Board of Governors, presented their recommendation that $700.00 of the meeting funds be deposited in a special interest bearing account in the Mellon National Bank and that the remainder be left temporarily in the Chapter's checking account. Upon vote, this recommendation of the Board of Governors was passed.

President Tennant suggested the appointment of a Current Events Committee to consist of student members, who would be allowed approximately 15 min at each meeting to abstract some of the current technical literature. Secretary Rockwell was appointed chairman of the Committee.

The subject of Cross Connections in Plumbing was presented in a paper by T. M. Dugan, who began his discussion by defining a cross connection and explaining the potential dangers to public health resulting from such connections. The paper was illustrated with slides showing how cross connections occur in common plumbing fixtures and how the fixtures can be redesigned to prevent cross connection.

Following Mr. Dugan, Prof. C. M. Humphreys, in a prepared discussion, described cross connections which frequently occur in air conditioning equipment such as air washers and condensers. He also exhibited several vacuum breakers designed to make water supplies safe against back siphonage.

After other discussion from the floor, Mr. Dugan demonstrated back siphonage with the use of a glass model.

The 35 members and guests present indicated that they thoroughly enjoyed Mr. Dugan's paper and the discussions.

February 10, 1936. The Pittsburgh Chapter was called to order at 8:00 p. m. in the auditorium of the U. S. Bureau of Mines by Pres. R. J. J. Tennant and 36 members and guests were present. The minutes of the January meeting were read by Secy. T. F. Rockwell and approved.

Reports were in order and Treas. J. F. S. Collins, Jr. stated that he had received $39.00 in payment of chapter dues.

M. L. Carr, Chairman of the Program Committee, announced that H. B. Meller would speak on Ventilation of Dusty Factories at the March meeting.

F. C. McIntosh, Chairman of the Membership Committee, reported names of candidates for membership and then briefly reviewed his work as Chairman of the Society's Membership Committee during 1935 which he had covered in his report given at the Annual Meeting in Chicago.

Prof. C. M. Humphreys, newly elected member of the A. S. H. V. E. Council, told of recent Council decisions regarding the selection of St. Louis as the meeting place for the Society in January, 1937 and the invitation from the Pittsburgh Chapter for the Annual Meeting of 1939. Professor Humphreys also reported on the action taken by the Council relative to the dues of Student Members.

In the absence of Chairman F. A. Gunther, F. C. Houghten reported for the Degree Day Committee stating that work started by the Pittsburgh Chapter had received recognition and that the local Committee had been made a sub-committee of the Society's Research Technical Advisory Committee on Heat Requirements of Buildings.

President Tennant reported for R. B. Stanger, Chairman of the Attendance and Social Committee, who was out of the City, that an expression of opinion was desired on the resumption of dinner meetings. Several members gave their views on the matter and the majority suggested that the final decision should rest with the Committee.

In taking up new business, President Tennant suggested, in view of the Council's decision regarding the Annual Meeting in 1937, that the Pittsburgh Chapter's meeting funds be invested in Government bonds or some similar security. This matter was referred to the Board of Governors for decision.

R. A. Miller was introduced by President Tennant and discussed the subject of Glass. In the relatively short time of 70 min, Mr. Miller told clearly and concisely the story of glass from its origin about 4,000 B. C. up to some very recent laboratory developments which were not yet in commercial production. The items of particular interest to heating and ventilating engineers were the improvements in double glazing, the use of new structural glass for both inside and outside wall facing, and the use of glass wool for heat insulation and air filtering. Mr. Miller pointed out the practical difficulties encountered with double glazing, but stated that when properly installed, it gave satisfaction, particularly in railroad service. He cited several investigations which indicated fuel savings of 20 per cent to 25 per cent resulting from the use of double windows or storm sash. Mr. Miller concluded his paper by telling of the latest developments in safety glass, glass for show windows, and methods for reducing the glare from automobile headlights.

Prof. H. S. Hower, Head of Physics Department, Carnegie Institute of Technology, in a prepared discussion, told of the latest developments in solid and hollow glass brick and tile. He described several recent projects where glass brick was used and mentioned that complete laboratory and field tests were under way to determine structural and heat transmission properties of the brick.

The two speakers covered the subject of glass so well that only a few questions were left for the audience to ask.

Before adjourning the meeting at 10:10 p. m. Pres. Tennant introduced Lt. Col. W. A. Danielson, President of the Washington, D. C. Chapter and newly elected Chairman of the A.S.H.V.E. Committee on Research.

St. Louis

February 11, 1936. Pres. C. R. Davis presided at the meeting of the St. Louis Chapter held at Garavelli's Restaurant, and 17 members and nine guests attended. The minutes of the previous meeting were read and approved.

President Davis reported that the Society's Annual Meeting in Chicago was a splendid success and stated that the 1937 Annual Meeting was scheduled to be held in St. Louis. Announcement was made that L. W. Moon had been elected to fill an unexpired term as a member of the A. S. H. V. E. Council.

Secy. R. J. Tenkonohy read a letter from Secy. A. V. Hutchinson regarding a visit of Pres. G. L. Larson to St. Louis on April 1 and also read a telegram from headquarters office concerning membership dues.

A meeting of the St. Louis Section of the *A. S. R. E.* on February 21 was discussed and H. J. Kipp, Secretary of the St. Louis Section of the *A. S. R. E.*, who was a guest, stated that the meeting was to be held at the Jefferson Hotel and arrangements were made for Secretary Tenkonohy to mail notices to the members of the St. Louis Chapter of the A. S. H. V. E.

The treasurer reported a balance of $411.44 as of February 11.

President Davis asked Mr. Moon to report on the 42nd Annual Meeting of the Society in Chicago. Mr. Moon stated that the meeting held the record for attendance and that approximately 60 St. Louisans were present. He related interesting humorous episodes involving chapter members and called attention particularly to the big job ahead of the chapter to spread the Spirit of St. Louis among the Society members at the Annual Meeting in January, 1937.

The meeting was turned over to D. J. Fagin, Chairman of the Program Committee, who introduced the speaker of the evening, F. I. Raymond, Chicago, Ill.

In his discussion of the Primary Zone Control and Common Faults of Steam Circulation, Mr. Raymond developed the need and method of varying the temperature of a steam radiator to control the heat output as the outdoor conditions change the heat requirements. The use of orifices and intermittent operation of cycling were described in detail, as well as the use of the control equipment in which the outdoor temperature and radiator temperature effect are connected to a device that regulates the furnace operation in the boiler.

Following the address, Mr. Raymond answered questions presented by those in attendance.

A rising vote of thanks was extended to the speaker and the meeting adjourned at 9:45 p. m.

Manitoba

March 4, 1936. The third meeting of the Manitoba Chapter was held at the Fort Garry Hotel, Winnipeg, with 13 members and guests present. Pres. J. B. Steele presided and welcomed the guests, who were H. D. Henion, Toronto, Ont., and Messrs. Scott and Yates, Jr.

President Steele requested all present to stand for two minutes of silence in respect to a fellow member of the Chapter, J. H. Leonard, who died February 24.

Following roll call the minutes of the previous meeting were read and adopted.

Secy. C. H. Turland gave a report on the 42nd Annual Meeting of the Society, held in Chicago, Ill., January 27-30, which he attended.

R. L. Kent announced that several prospective members hoped to have their applications filed by the next meeting.

The technical programs planned for future meetings were outlined by D. F. Michie.

It was moved by Mr. Michie, seconded by Secretary Turland, and carried that a committee be appointed to study air conditioning standards suitable for Manitoba. The following members were appointed and President Steele invited the committee to meet at his home on Wednesday evening, March 11; R. L. Kent, Chairman, H. R. Eade, William Glass, D. F. Michie, E. J. Argue, and C. H. Turland.

James Aitken, Frank Thompson and Secretary Turland were appointed as a Nominating Committee for the next annual election of officers.

Mr. Eade suggested that a visitors' register be obtained for the Chapter and Mr. Henion very kindly proposed that, as the first visiting member, he would present a suitable register, and his offer was promptly accepted.

Mr. Eade moved and Secretary Turland seconded a vote of thanks to Mr. Henion for valuable advice in connection with several suggestions gleaned from the Ontario Chapter's experiences and requested Mr. Henion to convey greetings to the Ontario Chapter from the Manitoba Chapter.

The secretary was instructed to advise the Ontario Chapter of future meetings with the hope that visiting members from Toronto would attend when in Winnipeg.

After two hours general discussion of several interesting subjects the meeting adjourned at 10:50 p. m.

Washington, D. C.

March 11, 1936. The regular monthly meeting of the Washington, D. C. Chapter was held at the Harrington Hotel and fifty-five members and guests were present at the informal dinner at 6:30 p. m. When the meeting was called to order at 8:00 p. m. by Pres. W. A. Danielson, who acted as chairman, there was an attendance of approximately seventy.

The minutes of the preceding meeting of the Chapter and of the Board of Governors on February 3 were read.

The treasurer reported a net balance of $38.55 in the treasury and announced that all those who were members in good standing would be given a Chapter membership card.

E. J. Febrey stated that the work of drafting the Chapter's Constitution and By-Laws was progressing and that the committee expected to present a complete report at the next meeting.

The chairman of the Membership Committee, R. H. Feltwell, reported that the committee was well organized and working effectively.

President Danielson appointed the following as members of the Nominating Committee for the election of Chapter officers: G. S. Frankel, A. E. Beitzell, and S. L. Gregg. The nominations of the Committee will be reported at the next regular meeting of the Chapter, when suggestions or additions by members will be made. Ballots will be forwarded by mail, and the tellers' reports rendered at the May meeting.

Mr. Feltwell raised the question of the issuance of guest cards to friends of members. President Danielson announced that the Chapter's policy regarding guest cards would be taken up by the Board of Governors and a definite practice adopted for the coming year.

Dr. C. A. Mills, University of Cincinnati, and Col. C. M. Walson, of the Surgeon General's office, were guests. Dr. Mills gave a short talk and President Danielson related a few interesting facts he had encountered on his trips in connection with the work of the A. S. H. V. E. Committee on Research. One of these sidelights was the method of sterilization of air by ultra violet rays.

W. E. Kingswell introduced the technical program for the evening, which was a talking picture on Automatic Controls, showing many combinations of automatic controls for heating, ventilating and air conditioning systems.

The meeting adjourned at 9:30 p. m. according to the report of Secy. M. D. Kiczales.

February 12, 1936. The Charter Meeting of the Washington, D. C. Chapter of the A. S. H. V. E. was held at the Kenwood Golf and Country Club, Bethesda, Md. Forty-seven members and their friends were present at the dinner at 7:00 p. m., and among the guests were C. V. Haynes, Philadelphia, Pa., Past President of the A. S. H. V. E., A. J. Offner, New York, N. Y., Treasurer of the Society, and A. V. Hutchinson, Secretary.

The meeting was called to order at 8:00 p. m. by Pres. W. A.

Danielson and the minutes of the previous meeting were read and approved. Vice-Pres. T. H. Urdahl reported on the meeting of chapter representatives held in Chicago during the Society's Annual Meeting.

President Danielson, Chairman of the Research Committee of the Society, spoke briefly concerning the work and objects of that Committee.

Mr. Offner presented the charter to the Washington, D. C. Chapter with an address of welcome and the charter was accepted on behalf of the chapter by President Danielson. An additional welcome on behalf of the national Society was given by Mr. Haynes.

A. V. Hutchinson, Secretary, announced that the Semi-Annual Meeting of the Society was to be held at Buck Hill Falls, Pa., June 22-24, and also outlined the Exchange Plan recently made effective between the *A. S. R. E.* and A. S. H. V. E., which upon payment of $4.00 makes mutually available the Refrigerating Data Book or THE A. S. H. V. E. GUIDE as the case may be, and the Journal of each Society.

A letter was read from headquarter's office which told of several amendments to the Society's Constitution and By-Laws relating to membership regulations and dues.

Short talks were given by E. J. Febrey, R. H. Feltwell and S. F. Gardner, all of whom have been members of the A. S. H. V. E. for more than 25 years.

The formal meeting was adjourned at 10:00 p. m. according to the report of Secy. M. D. Kiczales.

Western Michigan

March 9, 1936. Thirty-three members and guests were present at the meeting of the Western Michigan Chapter held in the Rowe Hotel, Grand Rapids, Mich.

S. S. Sanford, Detroit, Mich., gave a very interesting talk on Summer Cooling. There were also brief addresses by Prof. L. G. Miller, J. H. Van Alsburg, and S. H. Downs, followed by a general discussion of the subjects presented.

Secy. J. J. Troske reports that the April meeting is to be held in Holland, Mich.

February 10, 1936. Twenty-two members and guests were present at the meeting of the Western Michigan Chapter held in the Spanish Room of the Hotel Rowe, Grand Rapids, with a good attendance considering the weather conditions and snow blocked roads.

Prof. L. G. Miller gave a brief and capable summary of the various topics discussed in the technical papers presented at the A.S.H.V.E. Annual Meeting in Chicago and answered many questions.

Secy. J. J. Troske, who attended the Society's Annual Meeting as delegate, reported that Western Michigan Chapter was represented by 65 per cent of its membership in Chicago.

Chairman Miller of the Speakers Committee announced that arrangements were being made to hold the April meeting at Holland, Mich., and an inspection trip through the Lake Steamer North American and South American was planned.

The meeting adjourned at 10:30 p. m.

Western New York

March 9, 1936. A dinner meeting of the Western New York Chapter was held at the Touraine Hotel, Buffalo, N. Y., with Pres. W. E. Voisinet presiding.

After reading minutes of the previous meeting, communications and transacting other routine business, John Yuill was introduced and called attention to the annual meeting of the *National Association of Master Plumbers* to be held in Buffalo in June. The Chapter was asked to actively support and attend this meeting as a token to George Frank, Buffalo, president of the *N. A. M. P.*

President Voisinet then opened the meeting to a discussion of the Comfort Standards for Air Conditioning prepared by the chapter's committee. Many verbal and written comments were offered, which were recorded and will be presented at the next meeting of the Air Conditioning Committee. It was moved, seconded and unanimously passed that the Chapter endorse the Committee's accomplishments to date and it is anticipated that the Standards will be ready for presentation for final adoption at the April 13 Chapter meeting.

E. P. Hannig was presented by President Voisinet as the speaker of the evening. With appropriate introductory remarks, Mr. Hannig showed three reels of motion pictures describing the manufacture of wrought iron pipe from mine to the finished product. The picture depicted the old method of hand puddling and the new method of mechanical puddling.

The 52 members and guests in attendance accorded Mr. Hannig a rising vote of appreciation for his splendid presentation, according to the report of Secy. J. J. Landers.

President Larson Visiting Western Chapters

On March 31, Pres. G. L. Larson left Madison, Wis., on a trip that will take him to several mid-western and Pacific Coast cities where he speaks on the subject, Economics of Good Construction as Related to Residence Heating. His itinerary included St. Louis Chapter—April 1, Kansas City Chapter—April 2, Oklahoma City Chapter—April 3, Southern California Chapter—April 7, Pacific Northwest Chapter—April 14.

In addition to these appearances before local chapters of the Society he will address members of the Air Conditioning Society of San Francisco on the evening of April 9, and a noon meeting of the Seattle Engineers Club on April 14. President Larson's topic on these occasions will be the ABC of Air Conditioning.

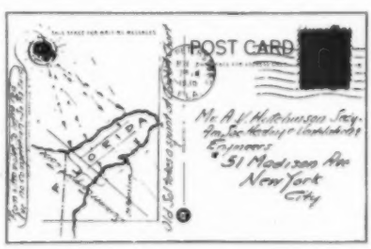
Travelers

W. H. Carrier and Mrs. Carrier are sailing from Australia April 4 and are scheduled to arrive in the United States April 19, after an absence of several months visiting Europe, Africa and other far away places.

Frank P. Keeney, president of Keeney Publishing Co., Chicago, and Mrs. Keeney are returning to the United States after several weeks absence visiting South American countries.

C. F. Roth and Mrs. Roth are enroute to California for a combined business and pleasure trip and plan to return from the Pacific Coast via Panama Canal.

The Sunshine City, St. Petersburg, Fla., has attracted several Society members and enjoyable visits are reported by Mr. and Mrs. D. S. Boyden, Boston and Mr. and Mrs. L. A. Harding,



Buffalo. Col. Boyden and Col. Harding will attest to the good condition of the local golf courses and the solar energy output at this famous city. Warren Webster, Sr., who with his family are winter residents of St. Petersburg, recently enjoyed a visit from Mr. and Mrs. Warren Webster, Jr. There should be evidence of Warren Jr.'s fishing skill real soon.

Transactions Sent to Members

During the first week of March distribution of TRANSACTIONS, Volumes 39 and 40, was started and members of the Society whose dues were paid for the years 1933 and 1934 received these volumes via Railway Express. Several copies have been returned because members have moved without leaving forwarding addresses and these copies are held pending instructions for reshipment.

The compilation of Volume 41 for the year 1935 is now under way and it is expected that printing will be completed during the summer months.

CANDIDATES FOR MEMBERSHIP

The Constitution of the Society as now amended, requires the following mode of procedure in voting on applicants for membership in the Society. All applications for membership are to be sent to the Secretary and the names of applicants and their references shall be printed in the next issue of the JOURNAL of the Society or sent to the members in other approved manner as ordered by the Council. When replies are received from references, the Candidate's application shall be submitted to and acted upon by the Committee on Admission and Advancement as soon as possible.

When the Committee on Admission and Advancement has acted favorably upon a Candidate's application and assigned his grade, the Council shall vote upon the election of the proposed Candidate for membership by letter ballot. During the past month 59 applications for membership have been received and the names of these men and their sponsors are published in the following list.

Members are requested to scrutinize the list with care. The Committee on Admission and Advancement, and in turn the Council, urge the members to assume their share of the responsibility of receiving these candidates into membership by advising the Secretary promptly of any whose eligibility for membership is in any way questioned.

All correspondence in regard to such matters is strictly confidential, and is solely for the good of the Society, which it is the duty of every member to promote.

Unless objection is made by some member by April 15, 1936, these candidates will be balloted upon by the council. Those elected to membership will be notified by the Secretary immediately after election.

CANDIDATES	REFERENCES	
	Proposers	*Seconders*
ADLER, J. C., Sales Mgr., Frigidaire Corp., New York, N. Y.	H. W. Fiedler H. G. Meinke	W. K. Walker T. W. Reynolds
ALLEN, D. M., Dist. Mgr., Ilg Electric Vtg. Co., Kansas City, Mo. (*Reinstatement and Advancement.*)	W. A. Russell David Caleb	C. W. Adams Carl Clegg
BAKER, G. R., Pres., G. R. Baker Co., Ltd., Toronto, Ont., Can.	M. F. Thomas W. R. Blackhall	M. W. Shears E. H. Gurney
BAKER, R. H., Student, Case School of Applied Science, Cleveland, Ohio	G. L. Tuve F. H. Vose (*A.S.M.E.*)	E. S. Ault (*A.S.M.E.*) A. O. Willey (*S.A.E.*)
BAMOND, M. J., Engr., Reynolds Corp., Chicago, Ill.	A. P. Brown Tom Brown	C. E. Price L. S. Ries
BREZINA, E. A., Student, Case School of Applied Science, Cleveland, Ohio	G. L. Tuve F. H. Vose (*A.S.M.E.*)	E. S. Ault (*A.S.M.E.*) A. O. Willey (*S.A.E.*)
BROCHA, J. F., Plbg. & Htg. Dept., Montgomery Ward & Co., Chicago, Ill.	H. A. Maccubbin F. J. Wilkinson	J. F. Firestone S. I. Rottmayer
BROWN, DAVID, Plbg. & Htg. Contractor, New York, N. Y.	F. B. Campbell W. W. Timmis	W. R. Zuhlke A. V. Leudemann (*Non-Member*)
COHEN, HARRY, Student, Case School of Applied Science, Cleveland, Ohio	G. L. Tuve F. H. Vose (*A.S.M.E.*)	E. S. Ault (*A.S.M.E.*) A. O. Willey (*S.A.E.*)
CROSBY, E. L., Consulting Engr., Henry Adams, Inc., Baltimore, Md.	L. G. Vance J. deB. Shepard	M. C. Gillett J. E. Axeman
CROSS, F. G., Sales Mgr. & Engr., Fulton Sylphon Co., New York, N. Y.	A. P. Livar H. W. Fiedler	A. J. Offner A. V. Hutchinson
CUMMING, F. J., Pres., Beecher-Cumming, Inc., Minneapolis, Minn.	G. C. Morgan H. E. Gerrish	F. B. Rowley A. B. Algren
CURTIS, W. A., Student, Case School of Applied Science, Cleveland, Ohio	G. L. Tuve F. H. Vose (*A.S.M.E.*)	E. S. Ault (*A.S.M.E.*) A. O. Willey (*S.A.E.*)
DANIELSON, E. B., Owner & Mgr., Air Conditioning Co., Russell, Kans.	W. F. Ryan W. A. Russell	C. W. Adams David Caleb
DEWAR, W. G., Mgr., Oil Burner Div., Canadian Fairbanks-Morse Co., Ltd., Montreal, Que., Can.	Thomas McDonald O. A. Fogarty	J. H. Fox A. W. Givin
DICKENSON, M. E., Vice Pres. & Gen. Mgr., Livingston Stoker Co., Ltd., Hamilton, Ont., Can.	Thomas McDonald J. H. Fox	H. R. Roth E. T. Flanagan
DOWNS, C. R., Vice Pres., Weiss & Downs, Inc., New York, N. Y.	W. E. Heibel C. F. Roth	M. H. Ittner (*A.I.C.E.*) A. E. Marshall (*A.I.C.E.*)
FOLLETT, T. L., Student, Case School of Applied Science, Cleveland, Ohio	G. L. Tuve F. H. Vose (*A.S.M.E.*)	E. S. Ault (*A.S.M.E.*) A. O. Willey (*S.A.E.*)
FOOTE, E. E., Chief Engr. & General Supt., Consumers Central Htg. Co., Tacoma, Wash.	C. W. May W. W. Cox	A. T. Forsyth D. C. Griffin
FREEMAN, J. C., Designer, O. W. Ott, Consulting Engr., Los Angeles, Calif.	A. W. Cooper O. W. Ott	J. T. Holmes (*Non-Member*) R. E. Phillips (*Non-Member*)
FULLER, J. H., Student, Case School of Applied Science, Cleveland, Ohio	G. L. Tuve F. H. Vose (*A.S.M.E.*)	E. S. Ault (*A.S.M.E.*) A. O. Willey (*S.A.E.*)

CANDIDATES

GARNETT, R. E., Sales Engr., Standard Asbestos Mfg. & Insulating Co., Kansas City, Mo.

GELTZ, R. W., Air Cond. Engr., York Ice Machinery Corp., Cleveland, Ohio.

GILL, E. F., Chief Draftsman, The Drayton Regulator & Instrument Corp., Middlesex, England.

HAMJE, M. C., Engr., Syska & Hennessy, New York, N. Y.

HARSCH, R. J., Chief Engrg. Draftsman, U. S. Navy Yard, Brooklyn, N. Y.

HARVEY, R. A., Student, Case School of Applied Science, Cleveland, Ohio

HERTZLER, J. R., Mgr. Air Cond. Div., York Ice Machinery Corp., York, Pa. (*Advancement*)

HUGHES, L. K., Gen. Mgr., Howard Furnace Co., Toronto, Ont., Can.

JACOBI, B. A., Student, Carnegie Inst. of Technology, Pittsburgh, Pa.

JONES, SPRAGUE, Pres., Sprague Jones, Inc., Toledo, Ohio

KAIN, E. M., Student, Case School of Applied Science, Cleveland, Ohio

LEE, R. T., Student, University of Illinois, Urbana, Ill.

LILJA, O. L., Mech. Engr., Toltz, King & Day, St. Paul, Minn.

LOCKHART, W. R., Sales Engr., York Ice Machinery Corp., Washington, D. C.

MACROW, LAWRENCE, Engr., Carrier Engrg. Corp., Newark, N. J.

MAROTTA, J. A., Student, Case School of Applied Science, Cleveland, Ohio

MCEWAN, E. E., Mgr. Air Cond. Div., Frigidaire Corp., New York, N. Y.

MITCHELL, J. G., Student, University of Minnesota, Minneapolis, Minn.

MOLLENBERG, H. J., Refrig. Engr., & Vice Pres., Mollenberg Betz Machine Co., Inc., Kenmore, N. Y.

NELSON, A. W., Sales Engr., American Radiator Corp., Albany, N. Y.

NITSCHKE, R. C., Engr., Socony-Vacuum Oil Co., New York, N. Y.

ORR, G. M., Consulting Engr., G. M. Orr & Co., Minneapolis, Minn.

PAUL, D. I., Sales Engr., Gurney Fdry. & Furnace Co., Ltd., Toronto, Ont., Can. (*Advancement.*)

PIETSCH, J. A., Consulting & Construction Engr., J. A. Pietsch, Inc., New Brighton, S. I., N. Y.

PRUDEN, BRADLEE, Salesman, Barber-Colman Co., Cleveland, Ohio.

RHOTON, W. R., Pres., The W. R. Rhoton Co., Cleveland, Ohio.

ROBINSON, D. M., Sales Engr., Buffalo Forge Co., Washington, D. C.

RUSSELL, W. B., Engr., Russell Furnace Co., Spokane, Wash.

SCHURMAN, J. A., Air Cond. Engr., York Ice Machinery Corp., Cleveland, Ohio. (*Advancement.*)

STERLING, J. G., JR., Student, Case School of Applied Science, Cleveland, Ohio

TANKER, G. E., Student, Case School of Applied Science, Cleveland, Ohio

TECKMYER, F. C., JR., Student, Case School of Applied Science, Cleveland, Ohio

VOLBERDING, L. A., Chief Air Cond. Engr., Norge Corp., Detroit, Mich.

WALKER, J. E., Student, Case School of Applied Science, Cleveland, Ohio

WENDT, E. H., Draftsman & Estimator, Wendt & Crone Co., Chicago, Ill.

WILLER, M. D., Student, Case School of Applied Science, Cleveland, Ohio

WITHERIDGE, D. E., Sales Engr., W. A. Witheridge Co., Saginaw, Mich.

WORTHING, S. L., Consulting Engr., Grand Rapids, Mich.

REFERENCES

Proposers	*Seconders*
W. A. Russell	Carl Clegg
C. W. Adams	C. A. Weiss
V. T. Kartorie	R. A. Wilson
J. A. Schurman	F. R. Dickenson
R. E. Ashton (*I.H.V.E.*)	K. G. Stephenson (*I.M.E.*)
B. H. Dyson (*I.P.E.*)	G. W. Betteridge (*I.P.E.*)
A. G. Syska	H. F. W. Dolk (*Non-Member*)
John James	E. J. Hughes (*Non-Member*)
Theodore Raynis	G. B. Pino (*A.W.S.*)
R. G. Dewdney (*Non-Member*)	W. C. Ryan (*S.N.A.*)
G. L. Tuve	E. S. Ault (*A.S.M.E.*)
F. H. Vose (*A.S.M.E.*)	A. O. Willey (*S.A.E.*)
G. E. Tuckerman	W. E. Barnum, Jr.
L. J. Du Bois	J. A. Schurman, Jr.
M. B. Watson	Thomas McDonald
H. R. Roth	C. R. Davis (*A.S.M.E.*)
T. F. Rockwell	R. J. J. Tennant
C. M. Humphreys	R. B. Stanger
A. L. Vanderhoof	K. W. Rohlin
H. C. Baker	G. B. Houliston
G. L. Tuve	E. S. Ault (*A.S.M.E.*)
F. H. Vose (*A.S.M.E.*)	A. O. Willey (*S.A.E.*)
W. H. Severns	H. J. Macintire (*A.S.R.E.*)
P. E. Mohn (*A.S.M.E.*)	O. A. Leutwiler (*A.S.M.E.*)
F. B. Rowley	H. M. Betts
H. E. Gerrish	R. E. Backstrom
G. E. Tuckerman	Benjamin Adams
S. E. Plewes	H. G. Black
L. J. Wachs	W. A. Grant
L. L. Lewis	J. J. Burke
G. L. Tuve	E. S. Ault (*A.S.M.E.*)
F. H. Vose (*A.S.M.E.*)	A. O. Willey (*S.A.E.*)
H. W. Fiedler	W. K. Walker
H. G. Meinke	T. W. Reynolds
F. B. Rowley	J. V. Martenis
A. B. Algren	B. J. Robertson (*Non-Member*)
B. C. Candee	P. S. Hedley
M. C. Beman	W. E. Voisinet
L. A. Welch, Jr.	A. J. Eckert (*Non-Member*)
E. W. Hollister	R. I. Scott (*Non-Member*)
B. H. Schulze	O. O. Oaks
L. W. Charlet	F. B. Howell
H. E. Gerrish	F. B. Rowley
G. C. Morgan	A. B. Algren
E. H. Gurney	W. R. Blackhall
M. W. Shears	William Philip
J. K. Peacock	John Rader (*N.Y.S.S.P.E.*)
C. V. Haynes	E. P. Neuschwander (*N.Y.S.S.P.E.*)
C. J. Braatz	C. F. Eveleth
M. F. Rather	Philip Cohen
Philip Cohen	G. L. Tuve
L. T. Avery	F. A. Kitchen
G. S. Frankel	T. H. Urdahl
R. E. Beitzell	M. D. Kiczales
R. C. Russell (*Non-Member*)	H. C. Bender (*Non-Member*)
J. H. Flanders (*Non-Member*)	G. M. Nason (*Non-Member*)
R. A. Wilson	G. L. Tuve
F. R. Dickenson	W. R. Beach
G. L. Tuve	E. S. Ault (*A.S.M.E.*)
F. H. Vose (*A.S.M.E.*)	A. O. Willey (*S.A.E.*)
G. L. Tuve	E. S. Ault (*A.S.M.E.*)
F. H. Vose (*A.S.M.E.*)	A. O. Willey (*S.A.E.*)
G. L. Tuve	E. S. Ault (*A.S.M.E.*)
F. H. Vose (*A.S.M.E.*)	A. O. Willey (*S.A.E.*)
W. G. Boales	G. D. Winans
F. J. Linsenmeyer	J. S. Kilner
G. L. Tuve	E. S. Ault (*A.S.M.E.*)
F. H. Vose (*A.S.M.E.*)	A. O. Willey (*S.A.E.*)
C. E. Crone, Jr.	J. J. Finan
John Howatt	B. L. Casey
G. L. Tuve	E. S. Ault (*A.S.M.E.*)
F. H. Vose (*A.S.M.E.*)	A. O. Willey (*S.A.E.*)
J. E. Emswiler	A. B. Knight (*Non-Member*)
Axel Marin	H. A. Randall (*Non-Member*)
P. O. Wierenga	D. L. Taze
J. J. Troske	O. D. Marshall (*Non-Member*)

Candidates Elected

In past issues of the JOURNAL of the Society the names of the following men were listed as Candidates for Membership. The membership grade of each Candidate has been assigned by the Committee on Admission and Advancement and balloted upon by the Council. We are now instructed by the Council to post herewith, as required by Art. B-III, Sec. 8, of the By-Laws, the following list of candidates elected:

MEMBERS

BACHMAN, FRED, Htg., Vtg. & Plbg. Contractor, Philadelphia, Pa.

BENNETT, C. A., Chief of Mech. Div., Div. of Municipal Archt., Dist. of Columbia

BOYLE, J. R., Asst. Chief Engr., Westerlin & Campbell Co., Chicago, Ill.

CARLOCK, M. F., Sales Engr., American Fdry. & Furnace Co., Bloomington, Ill.

EDWARDS, A. W., Dist. Mgr., The Trane Co., Cincinnati, Ohio

FLYNN, F. J., Htg. Engr., Missouri Water & Steam Supply Co., St. Joseph, Mo.

GOLDSMITH, F. W., Pres., The W. Clasmann Co., Milwaukee, Wis.

HELSTROM, H. G., Sales Engr., Wm. Bros. Boiler & Mfg. Co., Minneapolis, Minn. (*Reinstatement*)

HESSLER, L. W., Br. Mgr., The Trane Co., Milwaukee, Wis.

JUNKER, W. H., Chief Mech. Engr., Thos. Emery's Sons, Inc., Cincinnati, Ohio.

LAMBERT, R. D., Design Engr., American Radiator Co., New Rochelle, N. Y.

LAUTZ, F. A., Engr., Hamlin Air Cond. Co., Inc., Buffalo, N. Y.

LITTLEFORD, W. H., Htg. & Vtg. Engr., E. J. Febrey & Co., Washington, D. C.

MEINHOLTZ, H. W., Br. Mgr., York Ice Machinery Corp., Oklahoma City, Okla.

PARK, N. W., Htg. Engr., Phila. Saving Fund Society, Philadelphia, Pa.

PATTERSON, F. H., Sales Engr., Hoffman Specialty Co., Detroit, Mich.

PROIE, JOHN, Partner, Proie Bros. Furnace Co., Pittsburgh, Pa.

REDRUP, W. D., Pres., The Majestic Co., Huntington, Ind.

STOCK, C. S., Dist. Repr., The Herman-Nelson Corp., Bethesda, Md.

STOKES, A. D., Erection Supt., York Ice Machinery Corp., Washington, D. C.

WEDDELL, G. O., Br. Mgr., York Ice Machinery Corp., Pittsburgh, Pa.

WEITZEL, C. B., Owner & Operator, Cameron B. Weitzel, Manheim, Pa.

WESTOVER, WENDELL, Pres., Westover-Wolfe, Inc., Albany, N. Y.

ASSOCIATES

ANGERMEYER, A. H., Owner, Angermeyer Plbg. & Htg., Neenah, Wis.

BURR, KIMBALL, Western Mgr., Air Cond. Div., American Radiator Co., Chicago, Ill.

COVER, R. R., Repr., Ferro-Nil Corp., Washington, D. C.

CURTICE, J. M., New Business Repr., Public Service Co. of Colo., Ft. Collins, Colo.

DEWITT, E. S., Br. Mgr., American Blower Corp., Washington, D. C.

GODDARD, W. F., Gov. Repr., American Radiator Co., Washington, D. C.

GOTHARD, W. W., Managing Editor, Domestic Engineering, Chicago, Ill.

KARCHMER, J. H., Mgr. & Partner, The Karchmer Co., Springfield, Mo.

KISTLER, M. L., Contractor, Kistler's, Burlington, N. C.

PAULING, R. E., Sales Engr., U. S. Radiator Corp., Tulsa, Okla.

PEXTON, F. S., Sales Engr., Kansas City Gas Co., Kansas City, Mo.

RANK, A. I., Pres., Aetna Insulations, Philadelphia, Pa.

ROBB, J. E., Office & Sales Mgr., Minneapolis-Honeywell Reg. Co., Kansas City, Mo.

ROBERTS, H. P., Asst. Engr., Roberts-Hamilton Co., Minneapolis, Minn.

SHOEMAKER, F. F., Mgr., Air Cond. Co. of Tulsa, Tulsa, Okla.

SUTTER, E. E., Sales Engr., Mueller Brass Co., Washington, D. C.

WELSH, H. A., Sales Engr., Hudson Air Cond. Corp., Washington, D. C.

WHITE, H. S., Mgr. Sheet Metal Dept., Sellers & Marquis Roofing Co., Kansas City, Mo.

JUNIORS

ANSPACHER, T. H., Br. Mgr., Buffalo Forge Co., Kansas City, Mo.

EILS, L. C., Asst. Supt., Geo. J. Meyer & Son, Pittsburgh, Pa.

ERRATH, E. O., Htg. & Vtg. Engr., The Heil Co., Milwaukee, Wis.

FRIMET, MAURICE, Owner, S. I. Htg. & Air Cond. Co., Tompkinsville, S. I., N. Y.

GALE, H. A., Sales Engr., Hudson Air Cond. Corp., Washington D. C.

GIFFORD, W. R., Sales Engr., American Radiator Co., Washington, D. C.

HAWK, J. K., Engr., Hudson Air Cond. Corp., Washington, D. C.

KINCAIDE, M. C., Htg. & Air Cond. Engr., The Timken Silent Automatic Co., Detroit, Mich.

LAUER, R. F., Sales Engr., York Ice Machinery Corp., York, Pa.

LIEBRECHT, W. J., Asst. Gov. Repr., American Radiator Co., Washington, D. C.

MORSE, L. S., JR., Air Cond. Engr., Westerlin & Campbell Co., Chicago, Ill.

MURPHREE, R. L., Design Engr., C. P. Lichty Engrg. Co., Inc., Birmingham, Ala.

ROBINSON, J. A., Air Cond. Engr., Australian Gas Light Co., Sydney, N. S. W., Australia.

STOKES, ARLEDGE, JR., Engr., B. Segall Air Cond. Co., Shreveport, La.

THUNEY, F. M., Sales Engr., W. E. Kingswell, Inc., Washington, D. C.

TRAMBAUER, C. W., Sales Engr., Hoffman Specialty Co., New York, N. Y.

STUDENTS

ADAMS, B. C., JR., Student, University of Oklahoma, Norman, Okla.

CLIPPINGER, J. V., Student, Carnegie Inst. of Tech., Pittsburgh, Pa.

CRICHTON, H. C., Student, Carnegie Inst. of Tech., Pittsburgh, Pa.

DEMERIT, R. N., Student, Carnegie Inst. of Tech., Pittsburgh, Pa.

HOPKINS, F. L., Student, University of Minnesota, Minneapolis, Minn.

KRINTZMAN, HARRY, Student, Carnegie Inst. of Tech., Pittsburgh, Pa.

MAYES, CURTIS, Student, University of Oklahoma, Norman, Okla.

PARSONS, L. D., JR., Student, Purdue University, West Lafayette, Ind.

SALZER, A. R. JR., Student, Carnegie Institute of Technology, Pittsburgh, Pa.

SCHWARTZ, HAROLD, Student, Chicago Technical College, Chicago, Ill.

SEIDEL, G. E., Student, University of Minnesota, Minneapolis, Minn.

SHIELDS, C. D., Student, Purdue University, W. Lafayette, Ind.

STURM, WILLIAM, Student, University of Minnesota, Minneapolis, Minn.

VERVOORT, E. L., Student, University of Vermont, Burlington, Vt.

A lot of you won't read this because it looks like a lot to read

Still the few who do will be glad they did

NOW you have started, we are warning you it comes under the head of throwing out our chests.

This is 1936 isn't it? It was along about 1930, wasn't it, when Old Man Depression started shaking his fist under our noses? (Now don't think this is going to be another of those "business is better" blurbs).

Well, as we were saying, it was about then, that many of the boiler and heating concerns took to the cyclone cellars. Now and again one of them would put up a periscope to see which way the wind was blowing, and it generally was. While a few of the bravest, having a lot of time on their hands, worked out two or three new things, Burnham did 10.

Burnham didn't have any cyclone cellar, so the wind blew our hats off and scratched our heads at the same time. Those scratchings started us doing a lot of eight cylinder thinking.

As a result we started working on, and bringing out, new things. Some big. Some little. But we kept right on bringing them out. When a concern stays alive and doing like that, you can't exactly hold it against them. Sort of makes a fellow feel they must have the right stuff in them.

So here's where our blowing comes in. Hold on to your hat! Here are the things we brought out during the cyclone-cellar years.

1. The first completely Built-in Oil Burning Boiler having a real honest-to-goodness vertical fire travel.

2. That Slenderized Radiator that has kicked up so much dust because it takes up 40% less room, and heats 40% quicker. Made in 3, 4 and 5 tube sizes. Even yet no one is making a similar radiator in as complete a range of sizes.

3. Who but Burnham in the past off-years popularized the Taco-Tank? No one else even yet gives it a 6-year guarantee but Burnham.

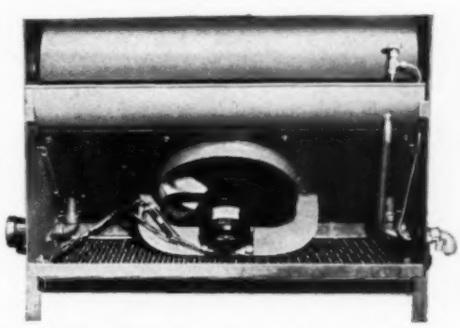
4. Then there is the Burnham Gas Boiler. It is the only one that today has a built-in cast iron draft diverter, and also gives positive control of both the primary and secondary air.

5. While about those other things, we made a Flexible Header. It's a complete one. Not just a skeleton header with a lot of things to buy before you can use it.

6. And all this time we were working on a radiator system that air conditioned. Not one that only puts a small amount of moisture in the air, but one that puts back all the heat takes out. One that also filter cleans the air and circulates it. One without any ducts, floor registers or wall grilles.

7. Bellows-type Vacuum Air Valves. Sure enough non-stickers. Guaranteed unconditionally for a year.

8. Burnham Radiator Valves both the standard type and Sta-Pak or packless. Made as Burnham makes everything with idea of service and lastingness.



This is something that has to do with the Burnham Unit Air Conditioner system. Right soon the Catalog will be ready. Might be a smart thing to have your name in for one.

9. Steel Oil Burning Boiler. Two pass tubular. An honest-to-goodness low water line boiler. Built-in Taco coil for hot water supply. Sound proofed and heat-insulated. Red jacket chromium trimmed.

10. Besides which there is that End-of-a-Cord heat. But of that another time. Don't want to tire you out "nohow"—As they say down South.

Burnham Boiler Corporation

IRVINGTON, N. Y. **ZANESVILLE, OHIO**

Representatives in all principal cities in the United States and Canada

Why

RIC-WIL Type "F" Conduit Means Dependable Protection for Underground Steam

- **Famous Ric-wiL Dry-paC Waterproof Asbestos Insulation—for high efficiency. (Conductivity only .36 BTU for low pressure.)**
- **Interlocking construction throughout—for stability.**
- **Famous Loc-liP side joint, continuous and visible.**
- **Best vitrified glazed tile—waterproof, everlasting.**
- **Approved, positive bell joint on conduit.**
- **Base drain foundation, substantial, non-settling—ample drainage.**
- **Practical pipe supports which snap in place quickly.**
- **Only three pieces to handle for each 2 ft. of system, only three joints—low installation cost.**

The above points emphasize the fact that Ric-wiL Conduit will keep YOUR underground steam lines tight, dry, and 90% or more efficient. Ric-wiL Standard Systems include optional types of insulation and can be furnished in either tile or cast iron to meet any practical requirements as to supporting strength. Ric-wiL also manufactures the self-contained, prefabricated Unit Steam Main, a complete unit system for underground steam transmission. Catalog describing all types of Ric-wiL Systems gladly furnished on request.

The Ric-wiL Co., Union Trust Bldg., Cleveland, Ohio
New York San Francisco Chicago
Agents in principal cities

REGISTERED IN U. S. PATENT OFFICE
RIC-WIL
CONDUIT SYSTEMS FOR UNDERGROUND STEAM PIPES

Equipment Developments

For your convenience in obtaining more information about any of this equipment, see coupon on page 110. Add the new products and companies listed here to your Directory Section which you received in your January 1936 HEATING, PIPING AND AIR CONDITIONING and thus keep your records of sources of supply up to date throughout the year . . . Single asterisk (*) indicates equipment not listed in Directory Section; double asterisk (**) equipment and manufacturer not listed.

Condensing Units Have Automatic Capacity Control

No. 685—New dual mounted condensing units were announced last month with capacities automatically controlled for efficiency and low operating cost in handling the variable air conditioning load requirements of spring, summer and fall weather. The assembly consists of two 4 cylinder compressors ("Freon" or methyl chloride) with motor and V-belt drive for each. Combined capacities range up to 60 hp with compressors graduated in size and fully automatic motor and temperature controls permitting three stage capacity reduction on all models.

Shell and tube type condenser-receiver with low resistance to water flow allows use of water cooling tower. Mechanical features include "Timken" tapered roller bearings on both thrust and blind ends of crankshaft to reduce power requirements and vibration; automotive-type cylinders and crankcase cast in one piece to assure lifetime alignment of crankshaft with cylinders; full pressure lubrication with built-in, positive gear oil pump; double-trunk type, semi-steel pistons fitted with high grade compression and oil wiping rings; and precision honed cylinder walls and drop-forged steel connecting rods and crankshaft.

The unit is assembled in various capacities from the maker's line of 77 models ranging in size from ¼ to 30 hp, two and four cylinder types.—Baker Ice Machine Co., 1509 Evans St., Omaha, Neb.

Manually Operated Remote Valve Control

No. 686—To supplement automatic control system, a new manually operated remote valve control has been developed. In many processes, automatic controllers stabilize the operation to such an extent that many non-critical flows may be governed by hand valves, which need be readjusted very infrequently; however, if these hand valves are not easily accessible, necessary adjustments may be neglected. Where these conditions exist, a remote valve control may be mounted on a centrally-located panel enabling resetting a valve several hundred feet away to control temperature, pressure, flow or liquid level using readings from recording instruments to guide in making the correct adjustments.

A feature of this air operated control is the precision of valve setting; it is easy to make a change in pressure on the diaphragm motor of the controlled valve as small as ¼ in. of water or less, which means that the valve opening can be altered by as little as a few thousandths of an inch to produce the exact desired flow, says the maker.—The Foxboro Co., Neponset Ave., Foxboro, Mass.

Four New Air Conditioning Units

No. 687—Four new models of "Ortho-Clime" air conditioning units include a 1 ton floor unit for both cooling and heating, "modernistic" in design, applicable for home or office use; two ceiling suspended units, available in 1½ and 4 ton cooling capacities; and a self-contained room cooler of about ¾ ton cooling capacity, requiring no plumbing or pipe connections.

A new series of central units with cooling capacities up to 12

tons for commercial and residential use will soon be available. —Fairbanks, Morse & Co., 900 S. Wabash Ave., Chicago, Ill.

Missing Pipes Located with New Detector

No. 688—Magnetic detector of extreme sensitivity and accuracy for locating distant or deeply-laid pipes is a surveying compass with an adjustable bar magnet for reducing the control effects of the earth's magnetic field, thereby rendering the needle more susceptible to magnetic disturbances produced by a missing pipe. The bar magnet is adjustable for height and azimuth.

Affixed to the compass box and turning with it are two radial fins of high permeability, low hysteresis magnetic material, serving as magnetic antennae. These fins effect a substantial increase in sensitivity, and are mounted on a crossbar.

The detector is sensitive to iron or steel pipe lines having any magnetic bearing, and at a considerable distance away. It may be used with or without electric current through the pipe, although the establishment of a small current makes for easier and more certain search. Non-magnetic pipes obviously require an electric current in conducting a search. Because of its sensitivity, the instrument cannot be used near trolley lines.

It is rarely necessary to work the detector at its extreme sensitivity. Easily manipulated and rapid in results, it will also determine the depth of a pipe within a few per cent, says the manufacturer.

The procedure followed is to establish the general bearing of the missing pipe from maps and ordinary compass directions. If possible, an electric current is then established between accessible hydrants and gates, using a switch and ammeter, with a lead wire at least 40 ft from the suspected pipe line; dry cells or an ordinary automobile battery suffice if the line has no break in electrical continuity, but in the latter event the detector functions without current.

The detector is set up at a point known to be at one side of the pipe line, with the compass box turned to have the fins at right angles to the line. The bar magnet is adjusted to give appropriate sensitivity and also to direct the needle to have the same general bearing as the line. This adjustment is held throughout the search. In shifting stations with the detector, the compass box is turned so that the needle takes the same scale position with no current in the pipe.

A curve is then plotted showing changes in current indication as the detector is transferred to convenient stations across the pipeline. The pipe is found directly below the peak in the curve.

When the true bearing of the pipe line is found by striking two or more courses of detector travel, then the actual depth below the detector can be readily discovered. This is done by moving the instrument over to the distant return wire, giving the wire the same bearing as that taken by the pipe line and suspending the wire over the detector at a height to duplicate the peak indications of the search curve. The distance between the wire and the compass box then equals the depth of the pipe below the compass box.

Pipes of 7 ft depths have been located within one pipe diameter. —General Electric Co., 1 River Rd., Schenectady, N. Y.

Larger Portable Air Conditioner Announced

No. 689—Increased cooling capacity, and the optional functions of heating and humidifying in winter have been incorporated in new "Model BA-100" portable air conditioner just announced. The unit is a companion to the maker's "Model BA-75" portable air conditioner introduced a year ago for the cooling of

Bond's Boston store, cooled by Baker Dual Unit.

Elias Rothschild & Co., Inc.
Designers and Engineers
Adams Engineering Co.
Engineers and Contractors

Smart merchandisers in the retail field are making ready for the *summer rush* by installing Baker System Air Conditioning. Here, for example is a big Eastern store which has assured itself low cost, dependable comfort cooling and extra profits with an automatic capacity control Baker Dual Unit . . . the year's most practical advancement in unit design for handling the variable load requirements of spring, summer and fall weather. Ask for specifications — Baker Ice Machine Co., Inc., 1509 Evans St., Omaha, Neb.

BAKER air conditioning

single rooms such as private offices, hospital and hotel rooms, and similar small spaces. Portability is attained by employing the principle of air cooling in the refrigerating system. The unit is 45½ in. long, 17¼ deep, and from 36 to 45 in. high, depending on the adjustment of the telescopic duct adaptor which is fitted under a window sash to bring in outside air.

Room air enters through a grille in the end of the cabinet, and is conditioned and discharged out the top. Outside air, drawn in through the rear duct adaptor, is used for two purposes, part of it is going to the room and part is circulated across the refrigerating unit and discharged outdoors. A new "air freshening" device incorporated in the unit consists of a hand-operated damper which can be opened in order to "pump out" a room; this becomes useful when several people have been smoking so much in a room that the normal introduction of outside air is inadequate, states the maker.

Outside air is cleaned by a replaceable filter in the duct connection, while room air is cleaned by a second replaceable filter directly under the return air grille. A feature is an electrical panel whose connections permit operation of the unit on either 110 or 220 volts a-c.

The cabinet design is in the modern motif, with straight grained walnut finish panels blending against a jet black top.—York Ice Machinery Corp., York, Pa.

Development for Preventing Valve Leakage

No. 690—To eliminate leakage in high pressure valves between seat ring and body, "Secoweld" has been developed. Instead of welding the seat ring into the body, a separate ring of "Seco" metal is welded in, which is threaded to take "Seco" metal seat ring. According to the maker, if a slight leak occurs it will not damage the threads, as the metal can resist the wiredrawing action of the steam; if necessary, the seat ring can be taken out, cleaned, and jammed back tight.—Spence Engineering Co., Inc., 110 E. 42nd St., New York, N. Y.

Unit Heaters in Capacities to 802,000 Btu per Hr

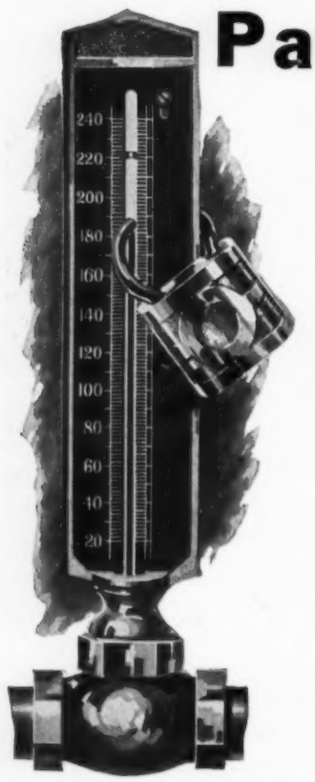
No. 691—New "Model FH" high velocity, low air temperature, unit heaters, available in a capacity range from 191,000 to 802,000 Btu per hr based on 2 lb steam pressure and 60 F entering air temperature, may be had either with or without patented "Thermadjust" control dampers for bypassing all or a part of the air handled around the heating element. For providing constant air circulation with the air temperature just high enough to supply the required heat to the space, the bypass damper can be manually controlled or can be furnished to operate with a thermostatically controlled damper motor.

The units are manufactured for floor mounting, vertical wall mounting, or horizontal ceiling suspension, and the position of each nozzle can be changed to control the direction of air flow. Construction features include frame work of heavy angle iron, electrically welded; casing of heavy gauge steel panels; extended copper heat transfer surface, with fins and tubes metallically bonded by a patented process; blowers mounted on a heavy shaft statically and dynamically balanced and driven by a ball bearing motor through a V-belt drive.—Young Radiator Co., Racine, Wis.

Quick Lock Nut

No. 692—The "Carey Quick-Lok" nut is aimed to speed up production of equipment on which it is used and improve the quality of the product. It is made from high carbon spring steel, tempered to give the required strength to the patented tongue. The guide lip is bent to an angle of 90 deg to keep the bolt from rocking or tilting when pressure is applied to the nut. Tongue and body are reinforced with ribs, and the tongue is at a slight angle so that its forked end easily engages the thread of the bolt.

It is easily applied, it being necessary simply to push the nut on the bolt and it fastens itself in place. If it is desired to



Padlock the Temperature

wherever you want it . . .

Set a Sarco Temperature Regulator for any temperature you wish to hold between 0 and 300° F. It will automatically maintain exactly that temperature in cookers, retorts, pasteurizers, water heaters, dryers or other steam heated apparatus. Spoilage due to fluctuating temperatures is absolutely eliminated.

Sarco Regulators can be adjusted anywhere within 25° above or below the calibrating point.

SARCO TEMPERATURE REGULATORS

are actuated by liquid expansion which gives more power to operate valves and greater sensitivity at all points of the range. They work with equal efficiency on steam, gas or oil.

Sarco Regulators are simple and inexpensive to install and operate. Have no stuffing boxes. Nothing to stick or get out of order. Will not be damaged by accidental over-heating. Require no electricity, air or water pressure to operate.

Furnished chrome-nickel trimmed without extra cost. Write for free trial offer and copy of catalog O-52.

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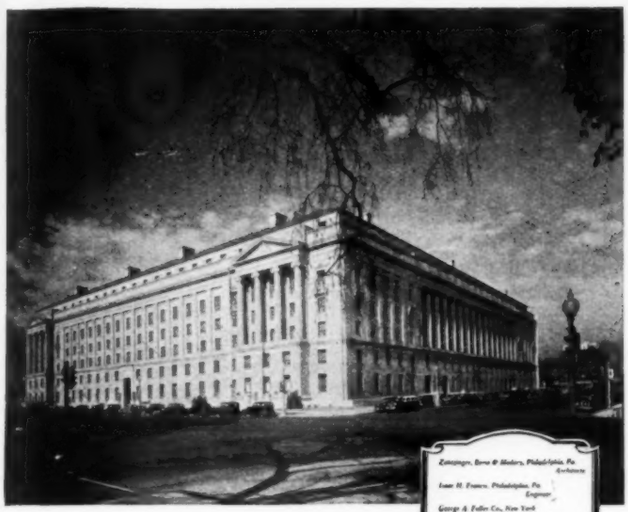

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FAN SYSTEM HEATING AND COOLING SURFACE

THE judicious selection of the best fan system heating surface, logically falls on Aerofin. Measured by the highest standards, Aerofin always lives up to specifications. This standardized light-weight fin-type surface has proved its high efficiency, dependability and long life in thousands of installations throughout the country.

For any job requiring forced fan heating or cooling, Aerofin is almost always the choice of experienced architects, consulting engineers and progressive heating contractors. If you do not know about Aerofin, investigate today—include it in the specifications for your next job. You will agree with others when they say that Aerofin gives them all they have wished for in a heating surface.

A complete line of equipment for heating and cooling is at your service. The home office in Newark or any of our branch offices will gladly send complete descriptive literature or render prompt personal and efficient technical co-operation. Simply write to the address below.

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This tree provides the right

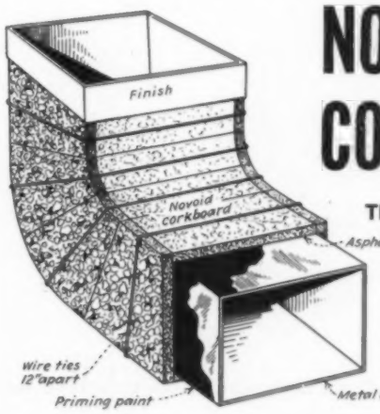
COVERING FOR DUCTS

Nature knows no better insulator than the bark of the cork tree. Its amazing cell structure forms an impassable barrier to heat—the one big reason Novoid Corkboard is so popular for the insulation of cool air ducts, as well as for all other parts of air-conditioning and ventilating systems requiring insulation.

Novoid is also moisture-resistant. It is structurally strong, light in weight. It is easy to erect. And it is fire-retardant.

Write and we'll send you a detailed drawing showing the simple application of Novoid for both square and rectangular air ducts, plus any other specific information you would like to have.

CORK IMPORT CORPORATION
330 West 42d Street, New York City



NOVOID CORKBOARD

THE NATURAL HEAT *Barrier* FOR SQUARE AND RECTANGULAR DUCTS

lock it in place like a rivet, the bolt is given a few turns with a screw driver.—The Philip Carey Co., Specialty Division, 400 N. Michigan Ave., Chicago, Ill.

Line of Convectors in Four Types

No. 693—New line of convectors in concealed, recessed, floor and wall types has been designed for beauty and efficient heating performance. Interchangeable grilles, ranging from conventional to modern classic, make it possible to harmonize the convector with the appointments of any room; four basic grille designs are provided from which it is possible to make up a wide variety of grille patterns. Lines and positions of enclosure rails and stiles lend themselves especially well to attractive color treatment, states the manufacturer.

Heating section is an all copper fin and seamless copper tube assembly, the fins, permanently bonded to the tubes by metal, having a smooth straight surface and spaced so that air flow is not impeded. Heavy flanged cornice strips bonded to the fins on top, bottom, and sides prevent injury to corners of fins, assure maintenance of fin spacing and prevent fins from "working" and causing noises as the radiator expands and contracts.—Modine Mfg. Co., 1750 Racine St., Racine, Wis.

Unit System of Pipe Insulation

No. 694—"Durant" insulated pipe has been developed to provide an economically installed unit system of underground or outdoor insulation for lines conveying steam, hot or cold liquids, brine or ammonia. Complete unit consists of specified pipe next to which has been applied insulation in proper thickness (general recommendation is 85 per cent magnesia for steam or hot water), and over the insulation has been applied an air-tight coating of asphaltum. To protect the entire unit from damage it is encased in a galvanized metal jacket. The entire system is built up at the factory and shipped to the job in standard or special pipe lengths.

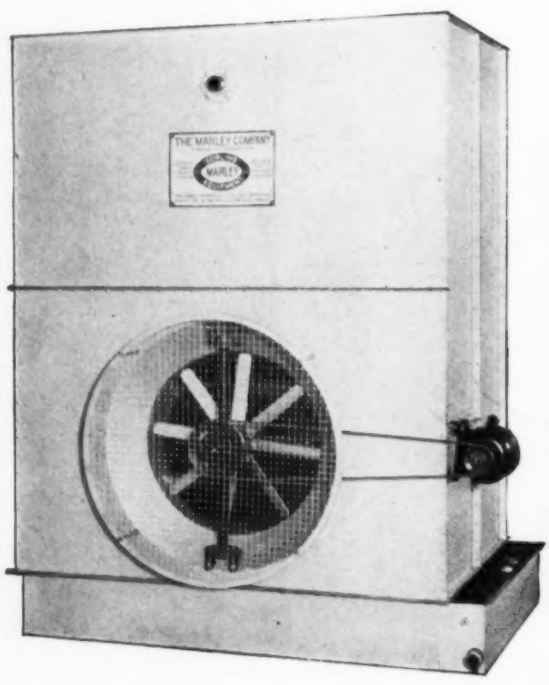
When used outdoors on overhead lines, the pipe is simply supported on towers, no other treatment being necessary. For oil lines where insulation is unnecessary, the pipe is coated with asphalt at the factory to prevent effects of electrolysis, corrosion or erosion. No tile, brick, masonry nor concrete work is necessary in its application when used underground except for piers to support pipe in case bottom of trench settles, says the maker. —Ehret Magnesia Mfg. Co., Valley Forge, Pa.

Motor Operated Valve Controller

No. 695—Two new types of multi-position controllers, known as the "Relatrol" and the "Balancer," produce a corrective movement in a valve or damper in exact relation to departure from the temperature setting, as measured by the actuating instrument. This corrective movement follows the temperature changes so accurately and promptly that it may be said to be "tied to the temperature", says the maker. In external appearance both units are alike. A special relay is supplied, wired into the circuit between the actuating instrument and the motor mechanism. This relay embodies an electrically controlled null-point, and as full line voltage is used in both relay and power motor, extra responsiveness is secured to repositioning demand. The mechanism is housed in a compact cast iron case to withstand the rough usage of industrial service.

The balancer is similar to the "Relatrol" except that it is provided with automatic means of load compensation and is recommended where load changes will be of considerable extent and duration.

A New Marley Tower



For the Smaller Air Conditioning Installation

A NEW Marley all steel, "small type" forced draft cooling tower!—equipped with Marley patented spray nozzles, Marley Multi-Blade fans, Marley zig-zag drift eliminator and redwood decking within the tower.

This tower is low and compact, easily assembled, operates with quietness and economy—has an unusually wide cooling range due to the combination of forced draft with interior decking and spray distribution.

Owners, builders and operators will find it ideal for the smaller air conditioning installations. Write for full details.

THE MARLEY COMPANY
1915 Walnut Kansas City, Mo.

MARLEY
SMALL SERIES
ALL STEEL FORCED DRAFT COOLING TOWERS

This
SUPER-SILVERTOP IS THE ONLY COMPLETE STEAM TRAP

I don't need . . .

ELBOWS OR NIPPLES because elbow connections are cast in the head of the trap eliminating excess pipe fittings and saving 40 to 60 minutes time per trap per installation. Super-Silvertop is used straight-in-line or as an elbow.

STRAINERS are unnecessary because the large drilled passages cannot become clogged with dirt and scale, a common fault with cored passages and small holes.

IT HAS A SNAP ACTION THERMAL AIR ELIMINATOR which assures instant heat to a steam system. It is the only steam trap that employs the Spencer disc for air elimination.

IT WORKS ON VACUUM—and any steam trap that works successfully on vacuum cannot leak steam. If a trap will not work on vacuum, it definitely leaks steam.

AND FINALLY the Super-Silvertop trap is easy to install on a steam line—easy to open for inspection without disturbing pipe connections and it is THE ONLY COMPLETE TRAP ON THE MARKET.

Write today for complete information.

THE V. D. ANDERSON CO.
1949 WEST 96th STREET • CLEVELAND, OHIO

CORINCO
Cork Pipe Covering Fits *SNUGLY*

Cold Line Insulation cannot be effective unless the insulation material fits snugly. The smallest air space between the pipes and covering will collect moisture which in turn forms ice and thus impairs the efficiency of the entire installation.

SPECIFICATION OF CORINCO CORK PIPE COVERING IS ASSURANCE FOR MAXIMUM EFFICIENCY AND MINIMUM MAINTENANCE

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155 East 44th St. New York City

Branches and Distributors in Principal Cities
Factory, Wilmington, Del.

Manufacturers of—Corinco Sheet Cork, Corinco Cork Pipe Covering, Corinco Granulated Cork.

The action employed by these mechanisms can be used in conjunction with many standard pyrometers, flow meters and other measuring instruments, by slightly modifying the contact mechanism. In certain instances the required instrument changes can be made in the field.

Where "Relatrol" action is supplied for manual remote control, a hand operated index and dial replaces the actuating instrument. —Automatic Temperature Control Co., Inc., 34 E. Logan St., Philadelphia, Pa.

Mineral Coated Welding Electrodes

No. 696—Recently announced heavy mineral coated electrode for shielded arc welding "Purox Type EHT" steel electrode is designed for downward position welding to produce welds of highest quality.

The mineral coating provides against atmospheric attack through the generation of reducing gases from the heat of the arc. The slag formed gives greater protection to the molten metal and results in welds generally more free from imperfections, states the maker, who summarizes the following advantages:

1. Freedom from excessive smoke and fumes.
2. The coating produces gases which protect the metal from atmospheric contamination of oxides and nitrides as it passes through the arc.
3. A heavy slag is produced which completely covers the molten metal and protects it from oxidation; and which also slows down the rate of cooling of the metal, thus permitting elimination of any dissolved gases.
4. Prevents excessive spatter loss, which enables the operator to use higher current values. This in turn speeds up the rate of deposition of the metal.
5. The melting point of the coating is such that the metal core melts before the coating. This forms a small crater about 1/16 in. deep which provides a mechanical means of protecting the deposited metal and also serves to stabilize the arc.
6. The composition of the coating is such that the slag tends to purify the deposited metal by removing oxides and gases, thus enabling the operator to produce weld metal free from porosity and slag inclusions.
7. The weld metal is usually deposited in a concave fillet, and washes up the sides of the groove. This characteristic of the metal minimizes or removes the chances of slag pockets or undercutting along the sides of the groove.
8. The slag is easily removed from the deposited metal. In fact, when it cools, the slag practically separates from the metal. This characteristic and also the small amount of spatter make it possible to clean the metal easily with one or two passes of a wire brush.

The electrode can be used with either alternating or direct current, reverse or direct polarity, and with either the weaving or beading method of deposition.—Linde Air Products Co., 30 E. 42nd St., New York, N. Y.

Welded Steel Boiler for Stoker Firing

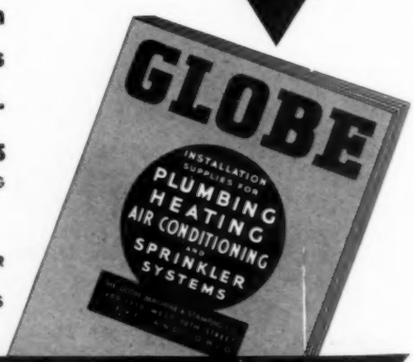
No. 697**—New welded steel, low pressure, fire tube, high firebox boiler, the "Benton Hi-Boy", has been designed especially for stoker firing and special emphasis has been placed upon combustion. The firebox, in addition to being of unusual cubic volume, is proportioned comparatively high and short to enable the stoker to operate at maximum efficiency, according to the manufacturer. The design is also said to lend itself to economical erection or installation, reducing the cost of installing the stoker.

Steam ratings range from 2190 to 30,360 sq ft. Furnace volume for the 2190 sq ft rating is 26.1 cu ft, and for the 30,360 sq ft rating, 273 cu ft.—Combination Boiler Co., Benton Harbor, Mich.

Before You Specify or Purchase Pipe Hangers, Pipe Clamps and Clips

SEND FOR THIS *Money-Saving Catalog*

THIS NEW CATALOG of Globe Pressed Steel Installation Supplies is of special interest to everyone installing Plumbing, Heating, Air Conditioning and Sprinkler Systems. Globe Parts insure greater strength, durability, lighter weight and better appearance at LOWER COSTS than many others designed for the same uses. All Globe Parts are approved by the National Board of Fire Underwriters.



PARTIAL LIST OF GLOBE INSTALLATION SUPPLIES

PIPE HANGERS
ADJUSTABLE SWIVEL HANGERS
SPLIT RING (CLEVIS) HANGERS
I BEAM CLAMPS
RETAINING CLIPS
UNDERGROUND HANGER CLAMPS
STEEL PIPE CLIPS
STEEL FLOOR AND CEILING PLATES
CEILING BUTTONS
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ADJUSTABLE CLIP BASES

GLOBE MACHINE & STAMPING COMPANY

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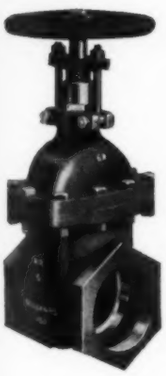
Before Voorhees, Gmelin & Walker, Engineers, chose Fairbanks Valves for the model office building of the New York Telephone Co. in New York, they made a searching investigation.

We showed them through our factories so they could see that Fairbanks Valves are made of the highest grade materials, made in a careful manner by men of long experience and carefully tested before leaving the factory. And we proved that long, dependable service, at low upkeep cost, had been given other users of

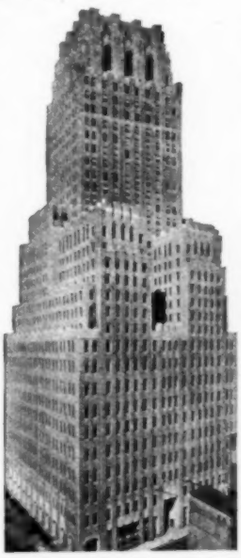
Fairbanks Valves



That careful buying pays is shown by the fact that their Fairbanks Valves are still giving entire satisfaction after many years of service.

You, too, would select Fairbanks Valves if you made a similar investigation. The best advertisement for Fairbanks Valves has always been the recommendation of enthusiastic users.

Write for names of users and catalog 21.



Voorhees, Gmelin & Walker, Architects and Engineers
Baker, Smith & Co., Heating Contractors
W. G. Cornell Co., Plumbing Contractors

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Manufacturers of Valves, Hand Trucks and Wheelbarrows

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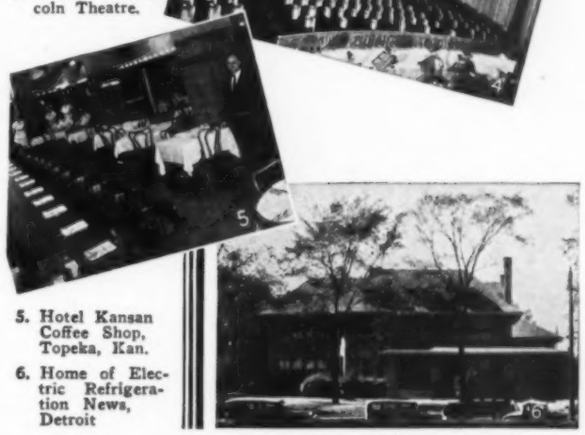
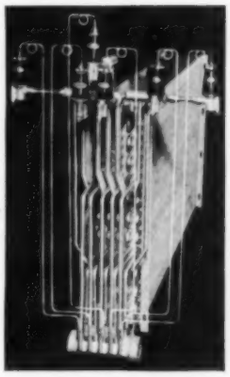
2. Jolly Cafe, Topeka, Kan.
3. 100-ton installation in Lincoln Theatre, Lincoln, Neb.
4. Interior of Lincoln Theatre.



5. Hotel Kansan Coffee Shop, Topeka, Kan.
6. Home of Electric Refrigeration News, Detroit

Fedders Air Conditioning Surface Has Gone to Town



All-copper construction, high prime surface, scientifically engineered manifolding, a complete line of standard sizes cataloged on a package basis . . . those are a few reasons why Air Conditioning Engineers are getting satisfaction with Fedders Surface. Fedders High Capacity Thermostatic Expansion Valves provide accurate refrigerant control and make a complete Low Side.

Write for Bulletin 91.

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Conventions and Expositions

Southern Industrial Show: April 6-11, Textile Hall, Greenville, S. C. Wm. G. Sirrine, President.

National Oil Burner Show: April 14-18, Convention Hall, Detroit, Mich. Managing Director, G. Harvey Porter, Oil Burner Institute, Inc., 30 Rockefeller Plaza, New York, N. Y.

Midwest Power Show: April 20-24, International Amphitheatre, Chicago, Ill. Management, Midwest Engineering & Power Exposition, 308 W. Washington St., Chicago, Ill.

Midwest Power Engineering Conference: April 20-24, Palmer House, Chicago, Ill. Secretary G. E. Pfisterer, 308 W. Washington St., Chicago, Ill.

Conference on Solid Fuels and Stokers: April 21-23, College of Engineering, University of Wisconsin, Madison, Wis. Chairman, Prof. L. A. Wilson, Mechanical Engineering Building.

Air Conditioning Conference: May 4-5, College of Engineering, University of Illinois, Urbana, Ill.

Air Conditioning Manufacturers' Association: Annual meeting: May 16, Hot Springs, Va. Headquarters Office, 915 Southern Bldg., Washington, D. C.

Refrigerating Machinery Association: Spring meeting, May 14-16, Hot Springs, Va. Headquarters Office, 915 Southern Bldg., Washington, D. C.

Heating, Piping and Air Conditioning Contractors National Association: Annual convention, May 25-27, The Bellevue-Stratford, Philadelphia, Pa. Educational Director, S. Lewis Land, 1250 Sixth Ave., New York, N. Y.

National District Heating Association: Convention and exhibit, June 16-19, Pantlind Hotel, Grand Rapids, Mich. Acting Secretary, Miss M. C. Stocker, 124 W. Fourth St., Greenville, Ohio.

National Warm Air Heating and Air Conditioning Association: Convention, June 17-18, Deshler-Wallick Hotel, Columbus, Ohio. Manager Director, A. W. Williams, 50 W. Broad St., Columbus, Ohio.

International Congress of Refrigeration: June 16-27, The Hague and Amsterdam, Holland. Organization Office, 107 Stolberglaan, The Hague (Holland).

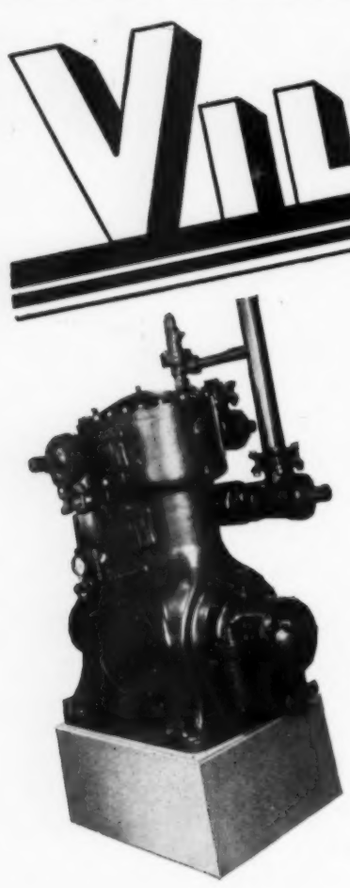
American Society of Heating and Ventilating Engineers: Joint semi-annual meeting with *American Society of Refrigerating Engineers*, June 22-24, Buck Hill Falls, Pa. Secretary, A. V. Hutchinson, 51 Madison Ave., New York, N. Y.

Short Course in Coal Utilization: June 9-11, University of Illinois, Urbana, Ill. A. C. Callen, Head of the Department of Mining and Metallurgical Engineering, 209 Transportation Bldg., Urbana, Ill.

American Society for Testing Materials: Annual meeting, June 29-July 3, Chalfonte-Haddon Hall, Atlantic City, N. J. Assistant Secretary, R. E. Hess, 260 S. Broad St., Philadelphia, Pa.

Great Lakes Exposition: July-September, Cleveland, Ohio. General Chairman, Dudley S. Blossom, Terminal Tower, Cleveland, Ohio.

National Association of Power Engineers: Annual convention and exhibit, August 31-September 4, Hotel Stevens, Chicago, Ill. Secretary, F. W. Raven, 176 W. Adams St., Chicago, Ill.



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Wherever "Freon" is utilized as the refrigerant in industrial and commercial applications of air conditioning, the Vilter "Freon" Compressor commends itself as the ideal refrigerating unit.

With features that are revolutionary in design and function, the new Vilter compressor is available in proportions so compact as to make its choice particularly outstanding for larger installations where floor space and head room are a factor.

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FRETZ-MOON PIPE

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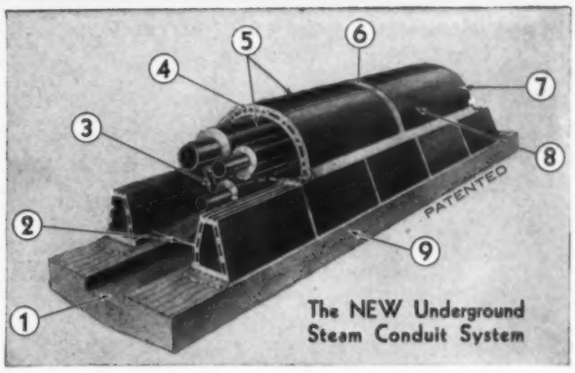
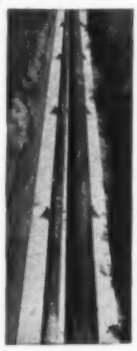


In our latest bulletin you will find facts on the above indicated details, 1 to 9 inclusive. Below we show

THREE SUCCESSIVE STEPS

in Therm-O-Tile construction. Note particularly that the piping and hollow tile conduit are *independently supported on the concrete base.*

Concrete foundation slab with internal drain channel. Pipe supports in place.



Piping on roller supports, accessible for welding and insulation.

Conduit envelope supported on slab. All joints water tight. Ready for back fill.

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Book Reviews

The Patient and the Weather

"The Patient and the Weather," by William F. Petersen, M. D., College of Medicine, University of Illinois. Vol. 1, Part 1, "The Footprint of Asclepius," $3.75; Vol. 1, Part 2, not off the press; Vol. 2, "Autonomic Disintegration," $6.50; Vol. 3, "Mental and Nervous Diseases," $5.00. Published by Edwards Brothers, Inc., Ann Arbor, Mich.

No matter how successful air conditioning engineers may have been in their studies of stable subjects, materials, and such, ultimate success will involve a still closer study of that vastly unstable subject, the reactions of man to air conditioning. The engineer in reaching out for help from the medical profession will not find himself slighted, but may find himself bewildered at the amount of literature already available touching on every conceivable subject. He might easily convince himself that the doctors, above all others, agree on nothing.

Now, the writer of this review cannot pose as an unbiased critic of these volumes, nor even as a capable reviewer, save from the engineer's standpoint. He was raised among the medical brethren and has continued to mix with them much to his own advantage. He finds it easy to sympathize with them in their efforts to help humanity. Now he only hopes there will be a quick growth of public sympathy for the air conditioning engineers in their efforts to help humanity.

But the human is not a stable subject, and it is because of this instability in humans that these volumes are of particular interest to the reviewer. There is no question but that the weather does affect people, that climatic conditions change the type. We know from study, as engineers, that the efficiency of workers is somewhat determined by atmospheric conditions, but it is worth much time and expense to learn why.

"The Patient and the Weather" deals with the bodily and mental troubles of those of us who, in our lesser or greater swings to adapt our personal physiologies to the swings of the weather fail to synchronize and find we are not in harmony with the universe. In other words we're sick. Since there are so many of us that are only just up and around and continuing business, and since all of us must sooner or later fit into the air conditioning picture, it is just as well to learn how the weather does affect us.

The first volume, "The Footprint of Asclepius," takes us back to Hippocrates and his deductions in connection with disease, the seasons, and the winds and weathers.

"There is nothing formidable, nothing musty, nothing ponderous about the Hippocratic texts. They are as refreshing and as stimulating as the pioneering age in which the author lived, and as his name, for that matter—'Horsetamer,' or, as we might say, 'Broncho Buster.' Remember that the Greeks of his time were still the 'wild horsemen of the seas' who roved every nook and corner of the Mediterranean shores."

The volumes deal particularly with the effects of irregular rise and fall in barometric pressures, the onslaught of the cold polar airs, and the softening reduction of warm southerly winds; the author takes his reader into unknown territory under capable but entirely human pilotage, with the way thoroughly charted by word and graph and comment. These are a few of the reasons these volumes are of great present day interest to the air conditioning engineer.—V. L. Sherman.

Taking the "PERHAPS" out of Humidity

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You are using a **perfect tool,** as accurate as a micrometer; as easy to read as a footrule.

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THE SUNDAY DAVENPORT DEMOCRAT

CONVICT 3 IN SEA DISASTER

New Cold Wave Nears; Deaths Grow

Facsimile of front page of The Davenport Democrat

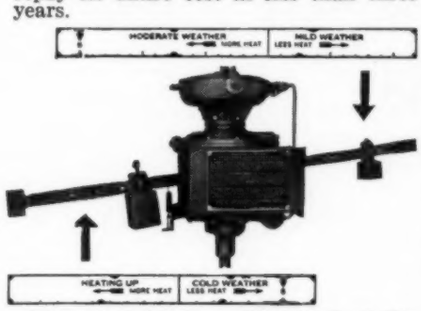
IOWA NEWSPAPER CUTS HEATING COSTS $517

Davenport Democrat Uses Webster Hylo System to Improve Heat Distribution, Lower Cost

Davenport, Ia.—The Democrat Building, home of the Democrat Publishing Company, publishers of the Davenport Democrat for more than 80 years, reduced the cost of heating during 1934-35 a total of $517, as the result of a Webster Heating Modernization Program which converted the installation into a Webster Hylo System of Steam Heating.

The modernization included necessary changes in piping to fit the installation to newspaper requirements, installation of radiator traps and accurately sized metering orifices in each of the 74 radiators and application of a central Webster Hylo Steam Variator Control.

The saving of $517 represents a 27 per cent reduction in cash expenditure for heating. At this rate, modernization will repay its entire cost in less than three years.



Illustrated at right is the Webster Hylo Steam Variator—a simple, rugged central control for use with Webster Systems where distribution of steam to all radiators is balanced by accurately sized metering orifices. The Hylo Variator Valve Operator (illustrated) automatically throttles a rugged motor-operated valve in the steam main.

There has been no "starving" of the heating system to effect these economies. As a matter of fact, the building is receiving substantially improved heating service with the Webster Hylo System.

Webster engineers cooperated closely with the owners and the heating contractors, the Ryan Plumbing and Heating Company, in meeting publishing requirements. The press room is kept at 80 degrees constantly. Savings are achieved without adverse effect on production.

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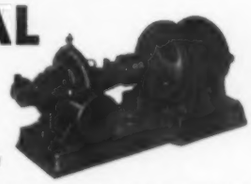

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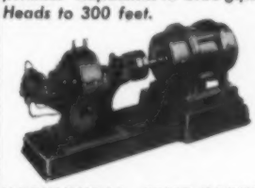

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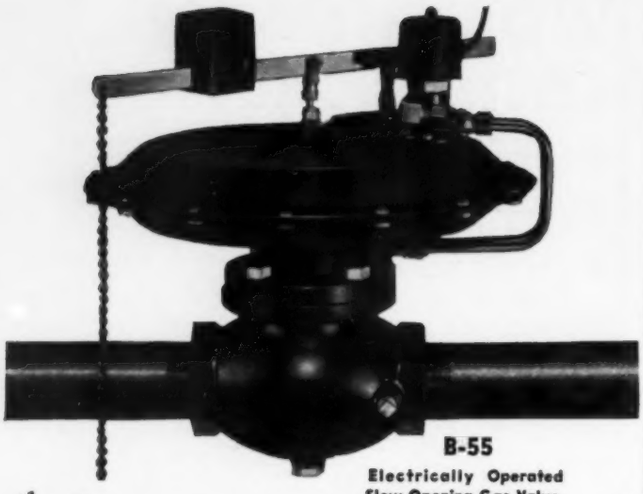

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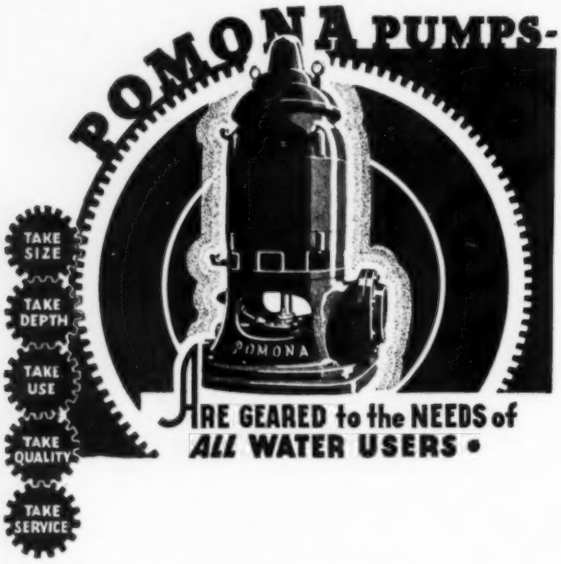

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Building Up Furnace Efficiency

"How to Build Up Furnace Efficiency," by Jos. W. Hays, Combustion Engineer. Published by the Dunes Publishing Co., P. O. Box 299, Michigan City, Ind. 18th ed., 559 pp., 5¼ x 7½ in., clothbound. Price $3.00.

Written in "popular" style and profusely illustrated with cartoon drawings, the author gives in this volume practical suggestions for operating boilers efficiently. This edition, the eighteenth, has been revised and enlarged, the book having been out of print for several years.

Why and how fuel is wasted, spotting and stopping fuel wastes, how to keep fuel waste stopped, and oils, gas and waste fuels are among the subjects covered. An appendix presents considerable data that could not readily be classified under any of the chapter headings, and includes a section on efficient operation of domestic heating plants.

Booklets, Reports and Papers

Piping Design Manual

"Pittsburgh Piping Design Manual," 69 pp., 8¼x10½ in., published by Pittsburgh Piping & Equipment Co., 14—43rd St., Pittsburgh, Pa. Price, $3.00.

This book—based on the work of E. A. Wert and S. Smith, with G. Sinding-Larsen and George W. Petrie, Jr., collaborating—has been compiled to assist the engineer in designing piping for flexibility, and to eliminate insofar as possible arduous and time consuming effort and yet assure adequate design. Data for the correct proportioning of a number of the commonly used piping structures using "superflexible" corrugated tangents with creased bends are given, and a series of curves for determining the flexibility of three plane smooth pipe structures is included. Equations and curves similar to those given but composed entirely of smooth pipe are developed in "A Manual for the Design of Piping for Flexibility by the Use of Graphs," by E. A. Wert, S. Smith and E. T. Cope, published by The Detroit Edison Co.

Chapter 1 discusses the application of corrugated tangents with creased quarter bends, Chapters 2 to 7 take up various cases involving 90 degree and U-bends, Chapter 8 gives comparison curves for effect on flexibility using short radius creased bends and corrugated tangents, Chapter 9 considers corrugated pipes in axial loading, and Chapter 10 is an explanation of constants.

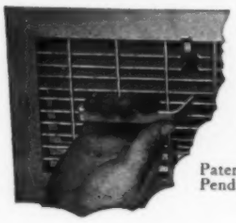
Chapters 11 and 12 are devoted to three plane pipe structures, and Chapter 13 to the location of welded joints. Chapter 14 concerns choosing an allowable working stress for pipe structures, and Chapter 15 flexibility factor curves effect on force and moment with variation of flexibility factor. Chapter 16 is a summary.

Several tables on the properties of pipe, and other pertinent data are included.

Manual of American Standards

"A Manual of American Standards Approved by the American Standards Association," 12 pp., 7½x10½ in., issued by American Standards Association, 29 W. 39th St., New York, N. Y.

This pamphlet gives an indexed list of engineering and industrial standards and safety codes approved by the *A. S. A.* Classifications are civil engineering, mechanical engineering, electrical engineering, automotive, transportation, ferrous and non-ferrous metallurgy, chemical industry, textile industry, mining, wood industry, pulp and paper industry, and miscellaneous, including symbols, petroleum products, dust explosions, gas appliances, noise, and others.



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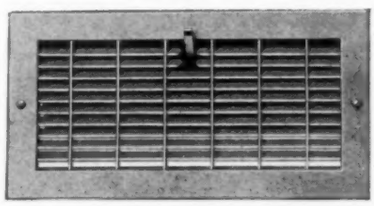

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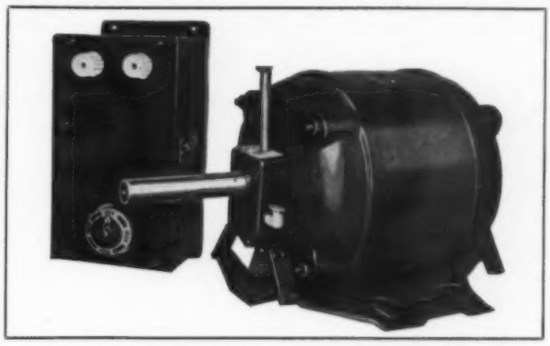

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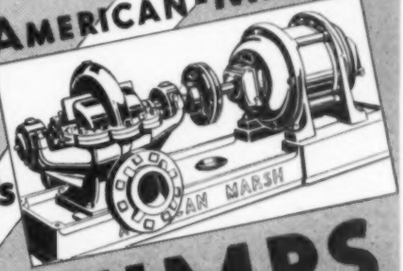

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- ☐ Tank Pumps (Steam)
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- ☐ Vacuum Heating Pumps (Steam)

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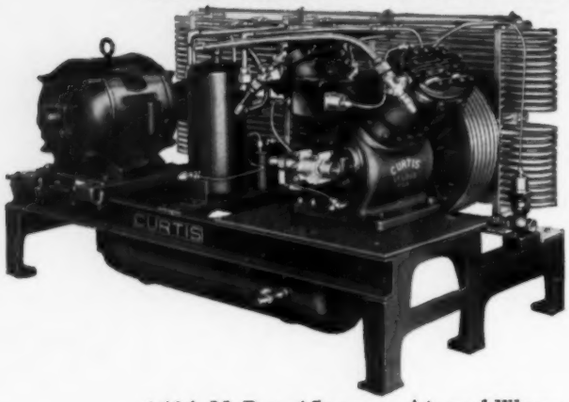

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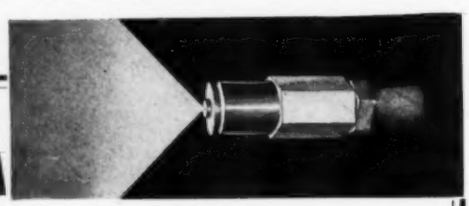

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FHA Annual Report

"Second Annual Report of the Federal Housing Administration," 52 pp., 6x9 in.

This second annual FHA report covers the calendar year of 1935. Subjects included are objectives and accomplishments, modernization credit insurance, mutual mortgage insurance (one to four family houses, large scale projects, and national mortgage associations), staff activities (including technical, legal, public education and economic and statistical research), and organization, personnel and finance. The appendix presents tables of modernization and repair notes insured by States; mortgages accepted for insurance, by States; a list of State enabling legislation, and a table and chart of building permits for new residential buildings.

In his letter of transmittal, Stewart McDonald, Administrator, says that at the close of 1935, total business transacted by the FHA amounted to $540,080,202, made up of modernization and repair notes insured, title 1, $254,070,729; home mortgages accepted for insurance, $170,594,864; mortgages accepted on large scale housing projects, $27,030,234; home mortgages in process of appraisal, $27,149,088; and home mortgages appraised, examined, and rejected, $61,235,287.

Recent Trade Literature

For your convenience in obtaining copies of bulletins, see coupon on page 110

No. 927. AIR CONDITIONERS: Buffalo Forge Co., 490 Broadway, Buffalo, N. Y. 24 p. bulletin on type "PC" cabinets for central air conditioning, available in capacities from 3 to 24 tons and in combinations for simple cooling or complete air conditioning. The equipment is described and illustrated in detail, and complete tables and charts are presented with examples of their application in selecting units. 14 pages are devoted to direct expansion cooling—temperature and water cooling—temperature capacity charts, and dimensions and other related data are presented.

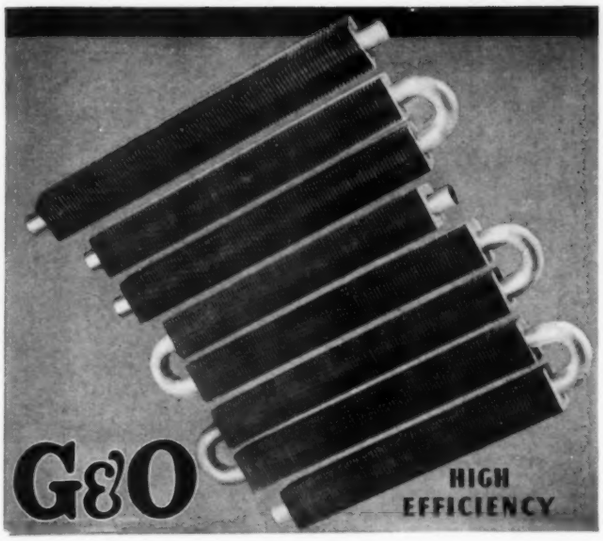
No. 928. AIR CONDITIONERS: The General Air Conditioning Corp., Apple St., Cincinnati, O. Leaflet describing "Alpine" summer air conditioners for cooling, dehumidifying and filtering available in wall and overhead type units. Installations in a beauty parlor, theater, office, restaurant and dress shop are pictured.

No. 929. AIR CONDITIONING: Carrier Engineering Corp., 850 Frelinghuysen Ave., Newark, N. J. 12 p. bulletin describing this company's various types of equipment for air conditioning, refrigeration and space heating—small room units for individual rooms and offices to large central station plants. Specifications and notes on applications are included.

No. 930. AIR CONDITIONING: Carrier Engineering Corp., 850 Frelinghuysen Ave., Newark, N. J. Spirally bound booklet on air conditioning department stores, a complete presentation including information on the scope and variety of this company's service, typical installations and data on them, and quotations from owners of department store air conditioning systems.

No. 931. AIR CONDITIONING: Carrier Engineering Corp., 850 Frelinghuysen Ave., Newark, N. J. Spirally bound booklet on air conditioning office buildings, a complete presentation including information on the scope and variety of this company's service, typical installations and data on them, quotations from owners of office buildings, and value of air conditioning to building owners and tenants.

No. 932. AIR CONDITIONING: Minneapolis-Honeywell Regulator Co., 2701 Fourth Ave., South Minneapolis, Minn.



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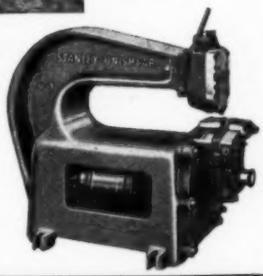

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No. 933. AIR VELOCITY METERS: Illinois Testing Laboratories, Inc., 419 N. La Salle St., Chicago, Ill. 4 p. bulletin on "Alnor Velometer," instantaneous direct reading air velocity meter, indicating directly on a scale air velocities in feet per minute, and available in shutter, orifice and tube types. Complete information on construction, uses and prices is given.

No. 934. ALLOY STEELS: International Nickel Co., Inc., 67 Wall St., New York, N. Y. Chart showing approximate relations between Brinell, Rockwell and Shore hardness values and the corresponding tensile strengths of constructional alloy steels, and two guides to the selection of nickel alloy steels and nickel cast irons.

No. 935. BOILERS: Manitowoc Boiler Works, Manitowoc, Wis. 4 p. bulletin describing "Model C" heating boilers in 22 sizes with capacities from 2,300 to 33,000 sq ft of radiation, which can be arranged for any type of fuel.

No. 936. BLOW-OFF VALVES: Edward Valve & Mfg. Co., Inc., 1200 W. 145th St., East Chicago, Ind. 18 p. catalog of blow-off valves for all American Standard pressures, describing in detail, features of construction, giving dimensions, list prices and weights, flange facings and flange dimensions and other pertinent information.

No. 937. CONTROL: Brown Instrument Co., Division of Minneapolis-Honeywell Regulator Co., Wayne & Roberts Aves., Philadelphia, Pa. Leaflet entitled "To Measure and Control Is to Economize," describing briefly flow meters, motorized valves, thermometers, hygrometers, CO_2 meters, potentiometers, pyrometers, etc.

No. 938. CONDENSATE RETURN UNITS: Ingersoll-Rand Co., 11 Broadway, New York, N. Y. 8 p. bulletin describing condensate return units, consisting of a receiver, a "Cameron Motorpump," and suitable automatic starting and stopping devices, for use in stores, schools, office buildings, plants and so forth. Equipment and its installation is described and dimensions, specifications and capacity tables given.

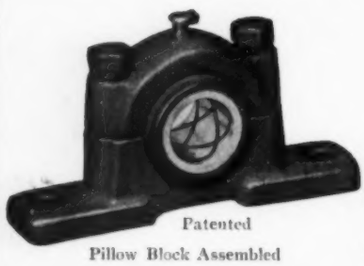
No. 939. ELECTRIC SCREW DRIVERS: Independent Pneumatic Tool Co., 600 W. Jackson Blvd., Chicago, Ill. 4 p. bulletin describing one-hand portable electric screw driver with driving range of No. 4 to No. 12 screws. Weight is 3½ lb and overall length 10½ in.

No. 940. GAUGES: American Schaeffer & Budenberg Division, Consolidated Ashcroft Hancock Co., Inc., 11 Elias St., Bridgeport, Conn. 12 p. catalog of "American" mercury pressure and vacuum gauges—"U" gauges, draft gauges and mercurial barometers—illustrating the various types, giving specifications and list prices.

No. 941. HEAT EXCHANGERS: The Duriron Co., Inc., 450 N. Findlay St., Dayton, O. 4 p. bulletin on heat exchangers available in a number of different corrosion resisting alloys, describing construction, applications, auxiliary equipment and giving specifications. Among applications are heating plating solutions, sterilizing vinegars, and heating metal pickling solutions.

No. 942. PIPE THREADING MACHINES: Landis Machine Co., Waynesboro, Pa. 8 p. bulletin featuring pipe threading and cutting off machine of semi-portable type, including detailed description of features and accessory equipment.

Bearing Requirements Met By RANDALL



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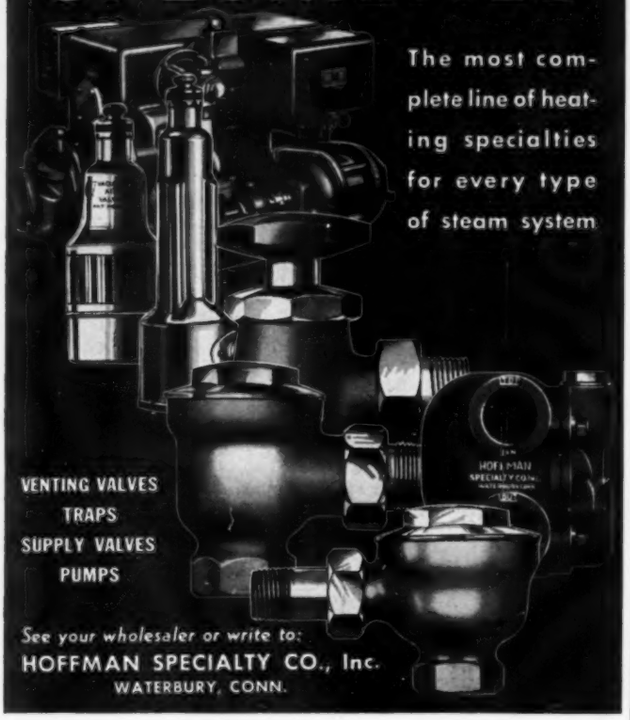

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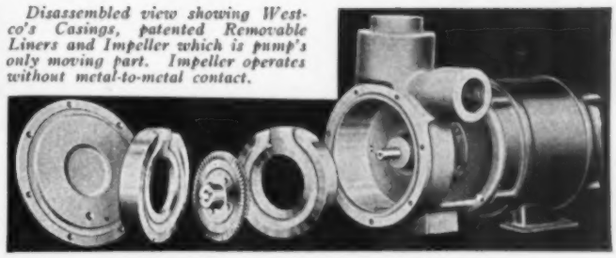

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No. 943. PUMPS: Westco Pump Corp., Front & Gaines Sts., Davenport, Ia. 8 p. bulletin on condensation return units for automatically returning to low and high pressure steam plants, condensation from radiation systems, heaters, steam coils, kettles, etc. Available in two lines, one with flexible coupling drive and the other of "Uni-Bilt" construction. Rating and selection tables and dimensions are given.

No. 944. PUMPS: Westco Pump Corp., Front & Gaines Sts., Davenport, Ia. 4 p. bulletin covering "Uni-Bilt" turbine pumps, direct connected to motor and particularly adaptable in connection with air conditioning and heating equipment. Selection and performance tables and a description of features of construction are given.

No. 945. PUMPS: Westco Pump Corp., Front & Gaines Sts., Davenport, Ia. 8 p. bulletin illustrating and describing turbine pumps of standard design, connected to motor by flexible coupling, the principal applications of which are transferring various process liquids; also applicable in connection with air conditioning and heating systems. Selection and performance tables, construction, specifications and description of features are given, as well as a description of increasing or decreasing capacity and head by means of removable liners.

No. 946. SEPARATORS: The Central Foundry Co., 420 Lexington Ave., New York, N. Y. Booklet describing "Solus" oil and gasoline separators for preventing oil and gasoline from entering drains and sewers.

No. 947. THERMOMETERS: H-B Instrument Co., Inc., 2518 N. Broad St., Philadelphia, Pa. 19 p. "Blue Book" of a full line of industrial, indicating and recording thermometers of various types, with complete information on each.

No. 948. TUBING: American Brass Co., American Metal Hose Branch, 414 Meadow St., Waterbury, Conn. 16 p. bulletin on seamless flexible tubing for conveying air, liquids, steam and gases, giving complete information on construction, advantages and applications, typical installations, and specifications.

No. 949. UNIT HEATERS: Carrier Engineering Corp., 850 Frelinghuysen Ave., Newark, N. J. 12 p. bulletin on "Kroy" type propeller fan unit heaters, describing features of construction, advantages and giving rating and selection tables and specifications.

No. 950. UNIT HEATERS: Carrier Engineering Corp., 850 Frelinghuysen Ave., Newark, N. J. 24 p. catalog of heat diffusing units or floor type unit heaters, with complete information on construction details, dimensions, ratings, capacity tables, recommended installation, practices, specifications, etc.

No. 951. WELDING FITTINGS: Bonney Forge & Tool Works, Forged Fittings Division, Tilghman St. & Meadow St., Allentown, Pa. 12 p. bulletin on "Weldolets" and "Thredolets," individual stock welding fittings, specifically designed to make branch connections such as tees, crosses, side outlets, etc. The "Thredolets" are similar to the "Weldolets" except their outlets are tapped to Standard Taper I. P. sizes. Advantages of their use and applications are described, and instructions for installing, stock sizes, prices, dimensions and weights are given.

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686	687	688	689	690	691	692	693	694
695	696	697	927	928	929	930	931	932
933	934	935	936	937	938	939	940	941
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